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The Pennsylvania State University
The Graduate School
Department of Architectural Engineering

A MODEL AIR FORCE CONSTRUCTION
QUALITY MANAGEMENT SYSTEM

A Thesis in
Architectural Engineering

by

James Bryant Pocock

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

May 1988



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ABSTRACT

The objective of this thesis is to develop a model quality management system for Air Force construction projects. The starting point is the Contractor Quality Control (CQC) system used by the Army and Navy to manage Air Force projects. Sub-objectives include defining the existing quality management systems used by the Army, Navy and General Services Administration (GSA), defining quality requirements, developing a system to numerically rate and compare the quality of projects in each system and finally, combining the best elements of each into a model system.)

Methods used include document review, interviews, questionnaires, project case studies, and analysis of case study results. The resulting project quality rankings correlated closely with my personal impressions and traditional indicators of quality. This shows that a quality assessment system can consistently rank project quality levels.)

The superior quality of the military projects studied was due to the military's three phases of inspection and a well-defined, consistently applied quality assurance system. There is more potential for improving overall quality in design and the design/construction interface, than in the construction quality control system. Recommendations address design flexibility, design

reviews, the design/construction interface, constructability, assessing project quality, post-occupancy inspections and recognition/accountability.

The military construction quality control system, while not perfect, is working well. In a model system, the Air Force should expand quality management to address all project phases.

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TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT.....	iii
LIST OF TABLES.....	viii
LIST OF FIGURES.....	ix
ACKNOWLEDGMENTS.....	x
 <u>Chapter</u>	
1 INTRODUCTION.....	1
Problem Statement.....	2
Evolution of Military and GSA	
Contractor Quality Control.....	3
Problems with CQC in Military Construction.....	6
Research Objectives and Methods.....	8
Objective 1.....	8
Objective 2.....	8
Objective 3.....	9
Objective 4.....	9
Expected Results.....	9
2 THE ARMY AND NAVY CONTRACTOR	
QUALITY CONTROL SYSTEMS.....	11
Introduction.....	11
Philosophy of CQC.....	11
Quality Control vs. Quality Assurance.....	11
Key Elements of a CQC System.....	12
CQC Organization.....	14
CQC Staffing.....	16
Control of Construction.....	16
On-site Construction.....	17
Construction Materials.....	18
Off-site Construction.....	18
CQC Reporting Requirements.....	19
The Daily QC Report.....	19
The QA Report.....	19
The Contracting Officer's Diary.....	20

TABLE OF CONTENTS (Continued)

Army and Navy CQC Differences.....	20
Comparison of CQC Requirements.....	20
Contractor Inspection System.....	21
Army CQC Systems.....	21
CQC Government Quality Assurance.....	22
Levels of Control.....	23
Title II - QA by A/E Firms.....	24
Methods of Enforcing CQC Requirements.....	25
3 THE GENERAL SERVICES ADMINISTRATION'S CONSTRUCTION QC SYSTEM.....	27
Introduction.....	27
Project Organization.....	27
Construction Quality Management.....	29
CQM Requirements.....	31
CQM Services.....	33
CQM Contracts and Award.....	34
Regional Inspection Team.....	35
4 RESEARCH METHODS USED.....	37
Introduction.....	37
Case Study Project Selection Criteria.....	38
Data Collection.....	39
Interviews.....	39
Interview Questions.....	40
Case Study Projects.....	41
5 RESULTS.....	43
Interviews.....	43
Military.....	43
GSA.....	47
Deficiency Ratings.....	50
6 ANALYSIS AND DISCUSSION.....	51
Comparison of Military and GSA Interviews.....	51
Defining Construction Quality.....	51
Agency Quality Values.....	52

TABLE OF CONTENTS (Continued)

	Weak Spots and Trends.....	53
	Comments on CQC.....	55
	Contractor Comments.....	56
	Case Study Projects.....	57
	Military.....	57
	Comptroller Services Center.....	57
	Wing Headquarters.....	59
	GSA.....	60
	Liberty Loan Building.....	60
	Border Station.....	61
	Summary.....	62
7	A MODEL QUALITY MANAGEMENT SYSTEM FOR AIR FORCE PROJECTS.....	65
	The Success of CQC.....	65
	Greater Impacts on Project Quality.....	66
	Sources of Quality Problems.....	67
	Recommendations.....	69
8	CONCLUSION.....	72
	Thesis Summary.....	72
	Implementing the Model Air Force Quality Management System.....	74
	Topics for Further Research.....	74
	Intent of the Work.....	75
	APPENDIX A: CASE STUDY PROJECTS.....	77
	APPENDIX B: INTERVIEW QUESTIONS.....	82
	APPENDIX C: PERSONS INTERVIEWED FOR QUESTIONNAIRES...	85
	APPENDIX D: CASE STUDY PROJECT SCORE SHEETS.....	89
	REFERENCES.....	106

LIST OF TABLES

<u>Table</u>	<u>Page</u>
3.1 GSA Construction Programs.....	27
5.1 Military Interview Results.....	44
5.2 GSA Interview Results.....	48
6.1 The Divisions Military and GSA Owning and Design / Construction Agencies Find Most Important to Quality.....	52
6.2 Overall Score Compililation.....	58
APPENDIX D:	
D.1 Comptroller Services Center, Score Sheet #1.....	90
D.2 Comptroller Services Center, Score Sheet #2.....	91
D.3 Comptroller Services Center, Score Sheet #3.....	92
D.4 Comptroller Services Center, Score Sheet #4.....	93
D.5 Wing Headquarters, Score Sheet #1.....	94
D.6 Wing Headquarters, Score Sheet #2.....	95
D.7 Wing Headquarters, Score Sheet #3.....	96
D.8 Wing Headquarters, Score Sheet #4.....	97
D.9 Liberty Loan Building, Score Sheet #1.....	98
D.10 Liberty Loan Building, Score Sheet #2.....	99
D.11 Liberty Loan Building, Score Sheet #3.....	100
D.12 Liberty Loan Building, Score Sheet #4.....	101
D.13 Border Station, Score Sheet #1.....	102
D.14 Border Station, Score Sheet #2.....	103
D.15 Border Station, Score Sheet #3.....	104
D.16 Border Station, Score Sheet #4.....	105

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1.1 Quality Control Costs Before and After CQC.....	5
2.1 CQC Project Organization.....	15
3.1 Traditional GSA Project Organization.....	30
3.2 GSA CQM Project Organization.....	32

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Chapter 1

INTRODUCTION

The United States Air Force spends over one billion dollars on construction each fiscal year (8). Either the Army Corps of Engineers (Army) or the Naval Facilities Engineering Command (Navy) (depending on geographic proximity) serves as the construction agent on Air Force projects. They administer the competitively bid lump-sum contracts, using the "Contractor Quality Control" (CQC) system.

Both the Army and Navy have their own versions of CQC which are almost identical (19). Contractor Quality Control was not developed to improve quality, rather it originated as a reaction to personnel and budget limitations (17, 28, & 29). CQC makes the contractor responsible for controlling, evaluating and correcting his own quality (21 & 25). The construction agency only assures the contractor's quality. With CQC there is an inherent conflict between the contractor's duty to the Government and his own interests in limiting costs (9, 18 & 28). Over fifteen years after its adoption, CQC continues to receive criticism from academic researchers (17), the engineering profession (18), and from within the Department of Defense (9 & 13).

The General Services Administration (GSA) does not place such trust in the contractor. It is the largest

government builder/owner outside the Department of Defense. All Federal contracts, including those awarded by the military and the GSA, are governed by the Federal Acquisitions Regulation. It normally requires competitively bid, lump-sum contracts. The GSA limits on contract administration costs are similar to, and in some cases tighter than, those of the military. However they do not allow the contractor to evaluate his own construction quality. GSA inspectors, or Architect-Engineer firms (A/Es) independent of the contractor, directly inspect the contractor's work and evaluate his performance (31).

Problem Statement

My thesis will investigate the following perceived problem:

The Army and Navy construct facilities for the Air Force using a quality control system dictated by their allowable contract administration fee structure, rather than quality requirements.

It will compare each system's success in achieving quality in construction. From an Air Force perspective, I will then combine the best elements of each to develop a model quality management system.

Evolution of Military and GSA
Contractor Quality Control

Both the Army and Navy have traditionally had large engineering organizations. When the Air Force became a separate service in 1947, its engineering function was much smaller than that of the other services. To avoid waste and redundancy the Government decided that the Army and Navy engineering organizations would manage construction projects for the Air Force. This remains the case today. Depending on location, either the Army Corps of Engineers or the Naval Facilities Engineering Command serves as the design and construction agent for Air Force construction projects.

The Army and Navy both used the traditional approach to quality control through the 1960's. The traditional approach relies on Government inspectors, supplemented with site visits by the designer, to enforce strict specifications (19).

In 1961 the Armed Services Procurement Regulation Committee added a clause to military construction contracts that made the contractor more responsible for quality control, by requiring him to provide an "adequate inspection system"(16). By 1970 both services were having trouble staffing and funding large construction inspection forces (16 & 18). The concept of the contractor being responsible for his own quality control became more

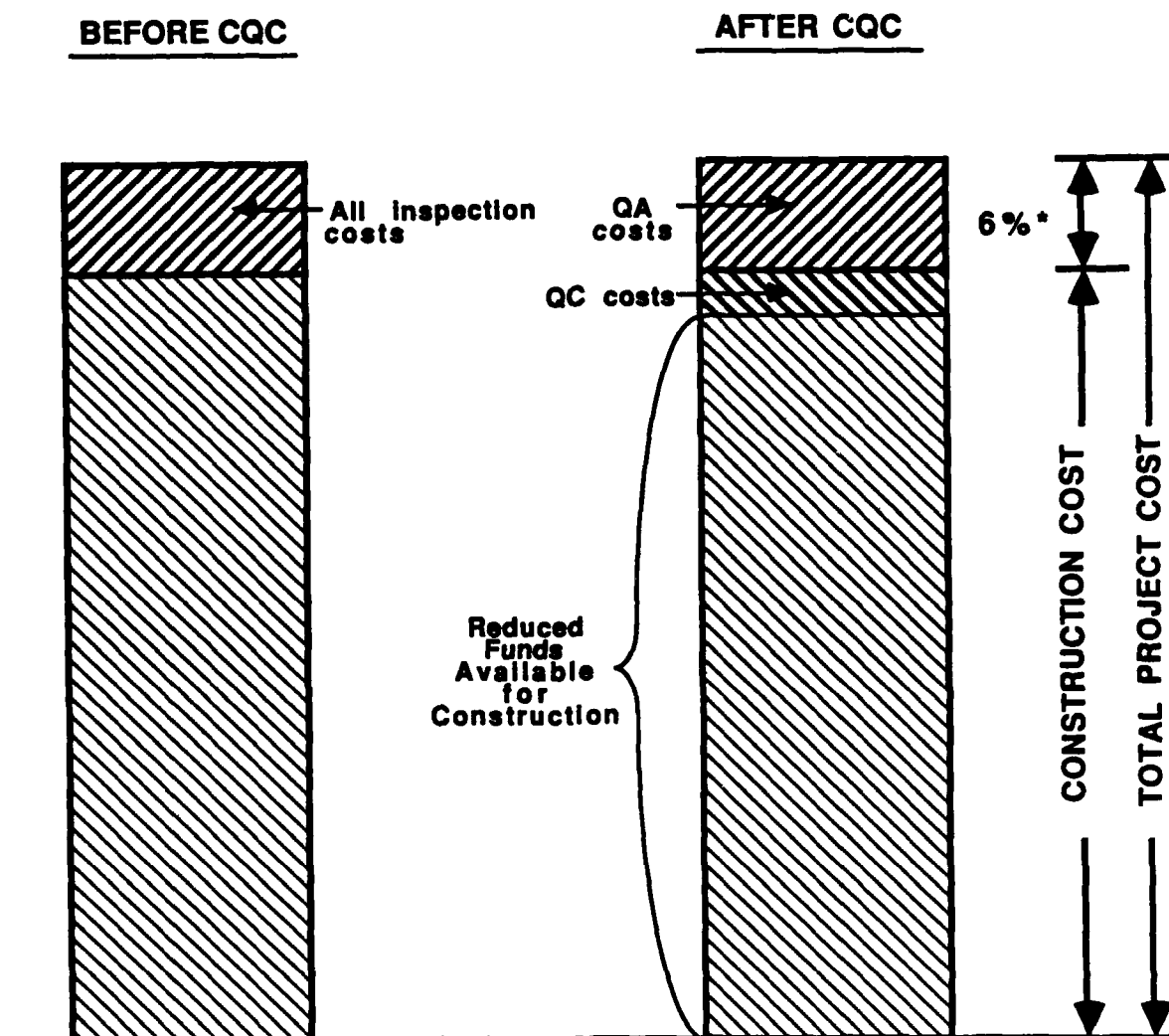
attractive because it would cut manpower and budgets.

In 1970 the Navy implemented the Contractor Quality Control (CQC) program, which it called

a management system established and maintained by the contractor that assures compliance with the contract plans and specifications. (17)

The Army followed suit quickly thereafter (19). In the Contractor Quality Control approach, the contractor provides a quality control plan, organization, and documentation, while the Contracting Officer (representing the Government) spot checks that the system is working (21). Some of the arguments later used to justify CQC ignored the fact that personnel and inspection cost savings were the major motivations in its adoption (28 & 29).

There were other savings besides the obvious cuts in personnel and inspection costs. On projects managed for the Air Force, the Army and Navy receive a percentage of the total project funds (usually about 6%) for their administration costs, including quality control. Despite their reduced responsibility for quality, and associated reduced costs, the Army and Navy continue to receive their 6%. The costs of quality control now performed by the contractor come out of the remaining project funds. The net result is that the Air Force now pays the construction agents the traditional rate for less service (see figure 1.1)(28).



* Six percent is for design/construction agency's supervision, inspection, and administrative overhead costs (SIOH).

Figure 1.1 Quality Control Costs Before and After CQC.

The General Services Administration makes a good comparison for four reasons. First, outside the Department of Defense it is the largest builder/owner in the public sector. Like the military, it must also award contracts according to the Federal Acquisitions Regulation (FAR). The GSA has survived the same, if not tougher, personnel and budget limitations as the military engineering agencies. Finally, and most significantly, the GSA quality control system is quite different.

Despite personnel and budget limitations, the GSA has maintained a more traditional quality control program. The GSA has never tried the CQC approach and is strongly against it. They consider it inappropriate for public, lump-sum, low-bid projects. They are trying alternatives, such as quality control management contracts, as a way of reducing personnel and costs while maintaining the same basic system (27 & 31).

Problems with CQC in Military Construction

The CQC system was originally justified by contract administration cost savings. But a study by the Logistics Management Institute in Washington, D. C., indicates that contract administration costs for complex projects in the range of two to four million dollars are higher under CQC than under the GSA system. Supervision, inspection, and administration costs were nearly 10 percent of construction costs for the Army, and about 15 percent for

the Navy. For GSA projects the size of typical Air Force projects, administration costs were only about 8 percent (3). The average Air Force project managed by the Army or Navy in fiscal year 1986 was worth \$3.36 million (4).

A 1984 Department of Defense Inspector General audit of construction inspection procedures (9) found

- deficiencies in newly constructed facilities accepted by DOD were of sufficient frequency and magnitude to warrant a concerted effort to improve inspections during construction
- 32 of 39 facilities reviewed had construction defects costing from \$1000 to \$200,000 to repair
- Two facilities, together costing \$8.8 million were completely unusable when accepted

A National Research Council study (2) found that in 1984 contract modifications, as a percentage of total project cost, averaged

- Navy 6.7%
- Army 5.8%
- Veterans Administration 4.4% (quality control similar to the GSA)
- State and Local Governments 3.9%
- Private Construction 3.8%

If contract modifications could be reduced from 6.7% to 3.8% on the typical Air Force construction project of \$3.36 million, it would mean a savings of \$97,440 per project. Were the higher rates for the Army and Navy due to changes in needs, frequent turnover of military personnel, new commanders with new desires, or might they

be using contract modifications as a way to correct quality deficiencies?

Research Objectives and Methods

The overall objective of this thesis is to develop a model quality management system for Air Force construction projects. There are four objectives to support this. The methods I used to achieve them are detailed.

Objective 1

Define the existing quality control systems used by the Army, Navy, and GSA. Methods: Research documents from each of the agencies explaining their quality control systems. Interview officials involved in quality control from each agency. Chapters 2 and 3 are the results of this first task.

Objective 2

Define required quality of the finished construction project. Methods: One obvious definition of quality is conformance with the requirements of the plans and specifications. To aid in comparison, quality requirements are defined by interviewing representatives of a project's owning agency, design/construction agency, its maintainers, and its users.

Objective 3

Compare the success of the two quality control systems. Methods: It would not have been possible, within the scope of this thesis, to review the hundreds of projects built under each of these systems every year. Selected detailed case studies of four similar construction projects, two from each system, provide an insight. While not completely representative of their respective quality control systems, these projects give some indication of general trends, as well as specific successes and failures. Numerically rate the success of each project's quality control system. The comparison of the two quality control systems combines these ratings with the comments of those I interviewed.

Objective 4

Combine the best elements of each system into a model quality management system for the Air Force. Methods: Those aspects of each system that contribute most to its success are combined. Further changes are recommended based on observed problems.

Expected Results

Until now there has been no alternative to the quality control system the Army and Navy chose to use on Air Force projects. I originally expected this thesis to

justify changes in the contractor quality control system. It does not. The model quality management system developed in this thesis justifies continued use of the CQC system. It goes further by recommending improvements in other project phases to form a comprehensive quality management system. Further study will be necessary to validate this work and justify the changes recommended. This thesis will generate discussion and interest in the ideas presented and further study among Air Force policy-makers.

Chapter 2

THE ARMY AND NAVY CONTRACTOR QUALITY CONTROL SYSTEMS

Introduction

The Army Corps of Engineers and the Naval Facilities Engineering Command build Air Force hangars, laboratories, runways, training schools, dormitories and other types of facilities, using their Contractor Quality Control (CQC) systems. This chapter attempts to give the current status of the CQC systems the Army and Navy use, which have evolved continuously since their adoption.

Philosophy of CQC

Both CQC systems share the philosophy that only the contractor can effectively control, and is therefore responsible for, the quality of his work. Similarly, the Government has an obligation to assure that this control is exercised and that the final product meets specifications (21 & 25).

Quality Control vs. Quality Assurance

With CQC there is a clear distinction between quality control, performed by the contractor, and quality assurance, performed by the Government. The contractor's responsibilities for QC include

1. Providing and maintaining an adequate inspection system (acceptable to the Government) to insure that the desired level of quality output is maintained. (25)
2. Maintaining records of all inspection work: to be complete and available for review by the Government. (25)

Government QA is "the process of confirming through some objective method of evaluation that the quantity and quality of goods and services received conform to the contract requirements" (25). At the same time, QA is measuring the effectiveness of the contractor's quality control system.

Key Elements of a CQC System

The Navy's CQC specification lists eight key elements in a CQC program (11, 19, & 21):

1. Contractor's construction and quality control (QC) organizations, and their interaction. The contractor must understand that he is responsible and accountable for quality control.
2. The contractor's CQC plan, approved by the Contracting Officer after Notice of Award. As a minimum it includes:
 - a. Contractor's letters of appointment to the CQC staff giving their duties and responsibilities.
 - b. Organization chart of the contractor's firm.
 - c. Names and qualifications of CQC staff.
 - d. Areas of responsibility and authority.
 - e. List of outside organizations (testing labs, surveyors, etc.).

- f. Submittals review procedure.
 - g. Personnel matrix of the contractor's project organization.
 - h. Inspection Schedule, keyed to the construction schedule and technical specifications.
 - i. Quality control documentation (sample forms, etc.).
- 3. Preconstruction CQC meeting. This is the first time the Government's quality assurance (QA) and the contractor's QC staffs meet. Rules and procedures are established and discussed in detail. In fact, both the Army and Navy have added a "Meeting of Mutual Understanding", which occurs shortly after the traditional pre-construction conference, to discuss CQC exclusively.
 - 4. Duties and responsibilities of the CQC staff. This includes all inspections and tests necessary to meet the specifications.
 - 5. Reports and documentation of QC and QA inspections. The primary report is the daily CQC report.
 - 6. Submittals of samples, shop drawings, manufacturer's information and certifications. The contractor is responsible for most submittals and must certify their conformance to plans and specifications.
 - 7. Enforcement of CQC. Including both contractor enforcement of the plans and specifications, and Government surveillance and enforcement of CQC requirements.

8. Contractor performance ratings. To document, motivate, and support future contract award/non-award decisions. The Army rates the contractor in terms of CQC, timely performance, effectiveness of management, compliance with labor standards, and compliance with safety standards. A contractor might be unsatisfactory in one area and still receive an overall satisfactory rating.

CQC Organization

Military construction projects using CQC are organized as shown in figure 2.1. The contract is between the Government (represented by the Contracting Officer) and the contractor. The Contracting Officer's Representative (COR) administers the contract and is responsible for QA. The QA representative performs the daily quality assurance inspections and reports. The CQC representative is directly responsible to the contractor for quality control. This person, or staff, must normally be organizationally separate from the contractor's construction operations. In other words, except in partial versions of CQC, the CQC representative cannot work for the construction superintendent. In this way, the Government attempts to limit the contractor's conflict of interest (11, 21, & 25).

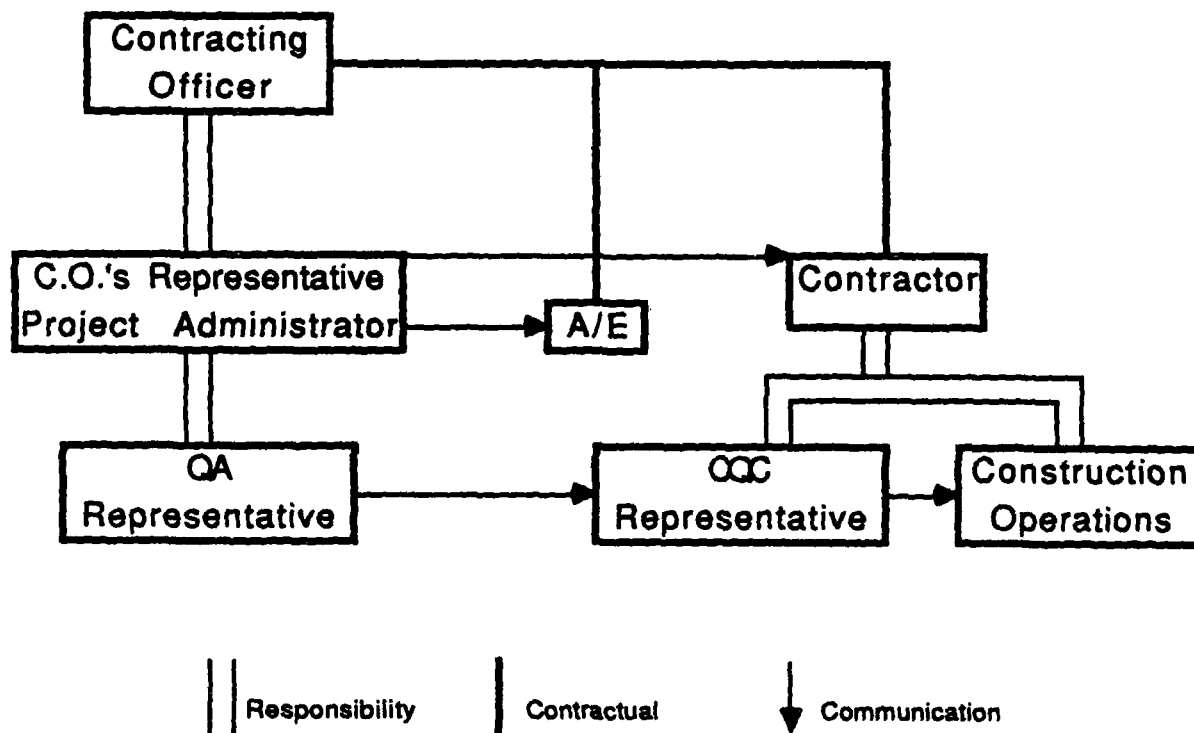


Figure 2.1 CQC Project Organization.

CQC Staffing

Both the Army and Navy require the contractor to appoint a full-time CQC representative. CQC representatives must be graduate engineers or architects, or have completed a building construction technology program with a specified number of years experience (6 & 11).

The latest version of the Navy's CQC specification requires an alternate CQC representative who will be on the site during any absence of the CQC representative. The Navy also now requires contractors to hire a submittals assistant until at least 95% of all submittals have been received and approved. Depending on the size and complexity of the project, both the Army and Navy may require additional CQC staff. For example, electrical or mechanical engineers might be needed to properly inspect electrical or mechanical systems (6 & 11).

Control of Construction

The contractor's CQC staff must perform three types of construction control, namely control of 1) onsite construction, 2) construction materials, and 3) offsite construction (9).

On-site Construction

Control of on-site construction consists of preparatory, initial, and follow-up inspections. The contractor's quality control representative (CQC rep) or staff conducts a Preparatory Inspection before each element of work begins. The Government QA rep will attend the first few Preparatory Inspections on a 24 hour notice by the contractor. The CQC rep performs the following functions (6, 11, & 19)

- Reviews contract plans and specifications.
- Checks that required submittals are approved.
- Examines materials.
- Checks that preliminary work is complete.
- Ensures that correct procedures will be used.
- Ensures that safety requirements will be followed.
- Prepares for required tests are ready.

Once work on a new segment of construction has begun, the CQC rep conducts an Initial Inspection. Again, the contractor must give the QA rep 24 hours notice. He checks worker's qualifications, compliance of work with plans and specifications, establishes a minimum acceptable level of workmanship, resolves any differences of interpretation, and enforces compliance with safety requirements (6, 11, & 19).

Finally he conducts Follow-up Inspections as necessary, making sure discrepancies he noted earlier have

been corrected and that none are recurring. In addition to these three types of inspection, the contract may require Special Inspection and Documentation for specific items (6, 11, & 19).

Construction Materials

The quality of construction materials is controlled through submittals of samples, shop drawings, manufacturer's information and certifications, and laboratory testing. The person reviewing submittals for the contractor and the CQC representative must certify by signature that each submittal complies with the contract drawings and specifications. Some contracts require that a registered architect or engineer review submittals before approval by the CQC rep. The CQC rep must also keep an updated log showing the status of all submittals. The contractor must arrange for a testing laboratory, approved by the Contracting Officer, to perform all required tests. The Contracting Officer spot-checks submittals and witnesses some tests. If he finds unsatisfactory results, he directs correction and resubmittal, and if not functioning properly, correction of the CQC program (11).

Off-site Construction

The CQC rep controls the quality of off-site construction by reviewing shop drawings and conducting

off-site inspections, as required by the specifications (11).

CQC Reporting Requirements

A CQC system comprises three main reports. These are 1) The daily quality control report, 2) The quality assurance report, and 3) The Contracting Officer's diary.

The Daily QC Report

The CQC representative describes the construction activities, the phase of QC inspection (preparatory, initial, or follow-up), tests performed, results of inspection and tests, and actions taken. The CQC representative submits it to the Government QA representative. The Navy also requires the contractor to keep an updated list of non-conforming work, showing when it was discovered and when it was corrected. All deficiencies on the list must be corrected before the Government will accept the project and make final payment (11, 19, & 21).

The QA Report

The QA representative concurs with the items as covered on the QC report, and notes any differences and communications with the contractor. The two reports should agree. If there are any differences the QA representative should resolve them immediately. The

QA report is submitted daily in the Army, as needed in the Navy (11, 19, & 21).

The Contracting Officer's Diary

The Contracting Officer (the Army Resident Engineer or the Navy Resident Officer in Charge of Construction) reviews both reports and writes "Memoranda of Significant Activities" on corrective action taken and conflict resolution. The Navy also uses a "Notice of Non-compliance" to document and officially notify the contractor of uncorrected or recurring construction deficiencies. The contractor must reply to the Non-compliance Notice by stating how and when he intends to correct the deficiencies (19).

Although the elements of a CQC program, CQC staffing, organization, control of construction and reporting are essentially the same in both the Army Corps of Engineers and the Naval Facilities Engineering Command, there are some differences.

Army and Navy CQC Differences

Comparison of CQC Requirements

The Navy spells out all of the requirements detailed above in a separate CQC section of the specifications.

The Army has virtually the same requirements, but they are scattered throughout the General and Special Provisions, as well as the technical specifications (19).

Contractor Inspection System

The Navy divides their CQC program into two levels. The Contractor Inspection System (CIS) is generally used for projects under about \$2 million (with some latitude for the Contracting Officer's judgment), and the full CQC system is used for larger projects. While the philosophy remains the same, CIS requires a less detailed or no QC plan, a smaller or no QC staff, and less paperwork. If the contractor's firm is small, the CQC rep may work directly for the project superintendent (12). By having these two levels, the Navy recognizes that smaller projects usually do not require a comprehensive CQC system. In fact, taken together, the CIS and CQC specifications give the local Contracting Officer maximum flexibility in setting QC requirements to meet specific project circumstances (25).

Army CQC Systems

The Army also has two versions of CQC, with a lower division set at \$1 million. But the differences between the partial and full systems are larger. For example, in the partial system, one person may function as both the project superintendent and CQC rep (30).

To this point we have focused on the quality control aspects of a CQC system. We now turn our attention to quality assurance.

CQC Government Quality Assurance

Government quality assurance can be divided into construction inspections and assessing the contractor's CQC program.

Government QA representatives are typically experienced construction inspectors. Besides their technical training, they also receive both formal and in-house instruction in CQC procedures and their roles in Quality Assurance. The Army and Navy give their quality assurance representatives formal training regionally at short (three or four day) intensive courses (25, 26, & 30). The QA representatives use checklists to highlight items of work to inspect under each section of the technical specifications. QA reps may typically cover three or more projects simultaneously, depending on their size. In addition to daily QA inspections, the Government inspects prior to monthly payments, at specific critical points in the contract, prior to final acceptance, and as needed depending on the contractor's QC performance (25 & 30).

Measuring the effectiveness of the contractor's QC program includes review of his QC plan, review of daily QC

reports, test results, and submittals, random surveillance, and preplanned visits to oversee critical portions of the work (10).

Levels of Control

The quality assurance function is arranged in three levels of control (19). The first level is the Contracting Officer who has direct supervision of the QA personnel. He monitors their reports, resolves conflicts and provides QA guidance.

Next is review of the QC and QA reports by district engineers (not used by the Navy). They look for problems, trends, and give help when needed. These regional offices also participate in the final inspection, often including specialists in generators, mechanical, fire control and elevator systems.

Finally, the Army Corps of Engineers (and to a lesser extent the Naval Facilities Engineering Command) area offices conduct extensive four- and nine-month post completion inspections (26). These inspections check for possible warranty items and provide design feedback. The Army's Office of the Chief of Engineers also conducts progress and post-completion inspections of selected projects. These inspections look for design problems, latent construction deficiencies, and potential maintenance problems. The results help spot problem trends and improve design and construction policy (19 & 26).

Title II - QA by A/E Firms

Title II, in this thesis, refers to the use of an A/E firm to perform portions of the quality assurance function, such as construction inspection, reviews of plans and specifications, construction photography, estimating change order costs, preparing record drawings, and surveying. The Government remains responsible for overall management and contract administration. The A/E firm may not direct or approve actions of the construction contractor (10). This technique is quite common in the private sector, with A/E firms performing all QA functions.

Factors the Army and Navy consider when deciding to use Title II services include; remoteness of project location, complexity of the project, current in-house workload and personnel limitations, and whether or not the services would be redundant with other Government inspection forces (10 & 21).

A/E firms interested in providing Title II services for a project must submit a QA plan (much like the contractor's QC plan). The contract is a negotiated fixed-fee type (21).

The advent of the Reagan Administration, with larger military construction budgets and simultaneous reductions in Government employees, increased the use of Title II services in military construction. When the Navy began

using Title II services for QA in 1983, it was only as a temporary measure to overcome civilian personnel shortages (21). Today the military's use of Title II for QA is increasing. The Navy includes Title II services in all contracts in case they decide to use them. Until recently, the Army seldom used Title II services. Now it is beginning to expand their use. The Army and Navy use Title II only for QA, not as a replacement for contractor quality control (25 & 26).

Methods of Enforcing QC Requirements

The contractor is expected to promptly correct work not complying with the plans and specifications or the QC requirements. When he does not, the Government has six methods of enforcing the QC requirements (21):

1. Direct rework of any items not conforming to the contract plans and specifications.
2. Refuse to accept and pay for unsatisfactory work or QC performance.
3. Remove incompetent personnel, including QC personnel.
4. Stop work if deficiencies will be covered or built upon. This is rarely done unless safety is an issue or tearing out nonconforming work would be extremely expensive.

5. Give the contractor an adverse interim contractor performance appraisal. Inform his home office and bonding company.
6. Terminate the contract. This is a last resort only and will often lead to litigation.

These methods vary in their degree of severity. The Contracting Officer must carefully consider each situation and its legal implications before choosing the appropriate method.

Chapter 3

THE GENERAL SERVICES ADMINISTRATION'S CONSTRUCTION QC SYSTEM

Introduction

The Public Building Service of the General Services Administration builds and maintains such facilities as office buildings, court houses and border stations for the federal government. The central office in Washington D.C. is responsible for major planning, policy, and overseeing the eight regional offices. Each regional office executes its own project design, contracting, and construction (27). The GSA has three construction programs as shown in Table 3.1 (31).

Table 3.1 GSA Construction Programs

<u>Program</u>	<u>Annual Size</u>
Projects under \$500,000	\$145 million
Alteration projects over \$500,000	\$250 million
New construction/purchase over \$500,000	\$140 million

Project Organization

For a typical new construction project of \$1 million or more, at least one GSA Contracting Officer's Representative (COR) will be on site full-time. On very

large projects, he may have a small staff including structural, mechanical or electrical engineers. The Contracting Officer's Representative may divide his time between several small jobs. He represents the regional office and is the decisionmaking authority on the job (27 & 31).

The letter used by the GSA's Public Building Service in Boston to designate the Contracting Officer's Representative lists the following responsibilities (16)

- a. Inspection and Acceptance: To inspect and accept all materials and workmanship (both in process and completed) and to reject same when they are found to be unsatisfactory and not in accordance with the contract. (This includes all testing).
- b. Labor Standards Interview: Perform required labor standards interviews and wage checks of contractor's employees.
- c. Administer contract day-to-day.
- d. Approve schedules, shop drawings, material samples, operating and maintenance manuals and other technical submittals from contractor.
- e. Monitor the schedule, determine and report progress, recommend payment, and recommend withholding from monthly payment for lag in progress. All payments will be recommended by the COR and authorized by the Contracting Officer.
- f. Issue change orders up to \$10,000 on work within the scope of the contract and grant any associated time extension.
- g. Conduct pre-construction conference and prepare minutes of meeting and any other delegations which are authorized in writing by the Contracting Officer. (pp. 1-2)

In the past, the construction engineer would have been assisted by a number of GSA inspectors, depending on the size of the project. The personnel reductions of the early Reagan Administration forced the GSA to gradually sacrifice its force of inspectors. Today the GSA often hires the A/E firm that designed a project to assist the construction engineer (27). Typically the A/E provides one or more technical inspectors and a secretary. The inspector keeps a daily log and informs both the construction engineer and the contractor's superintendent of any deficiencies. Both GSA projects studied in this thesis were managed using A/E assistance. The organizational relationships are shown in figure 3.1. There is a new GSA quality management system on the horizon.

Construction Quality Management

The GSA is in the process of changing to a new approach they call Construction Quality Management (CQM). At this writing, no new construction projects managed under CQM were yet available for study.

Under CQM, the GSA hires an independent A/E or construction management firm to manage all phases of a project from predesign through design, procurement and construction. There is no GSA construction engineer on site. The CQM firm performs all the former inspection and

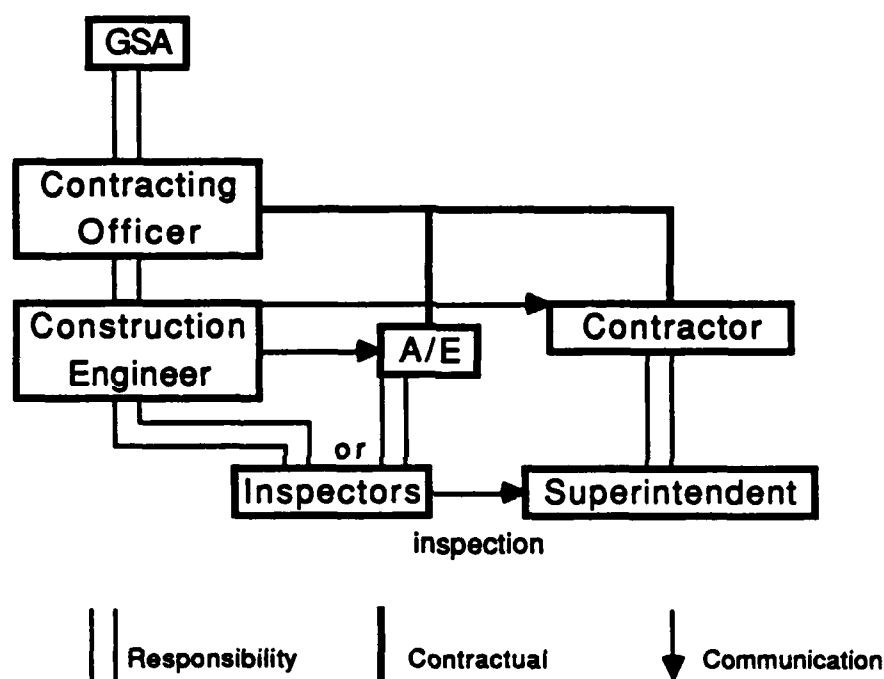


Figure 3.1 Traditional GSA Project Organization.

testing duties of the construction engineer (14). See figure 3.2 for a typical project organizational relationship diagram.

CQM Requirements

Like the quality control plan in CQC, firms interested in a project with CQM requirements must submit a Preliminary Management Plan covering (14)

- project definitions
- project objective
- responsibility outline
- organizational charts
- schedules
- cost control
- written procedures
- responsibility and liability
- key personnel
- staff
- ability to work at remote sites
- proposed project team(s)

In addition to the Project Management Plan, prospective CQM firms must detail their firm's organization, personnel policies and qualifications, experience on similar projects, and capabilities.

The GSA will provide key CQM personnel with one week's training in government procedures and policies (14).

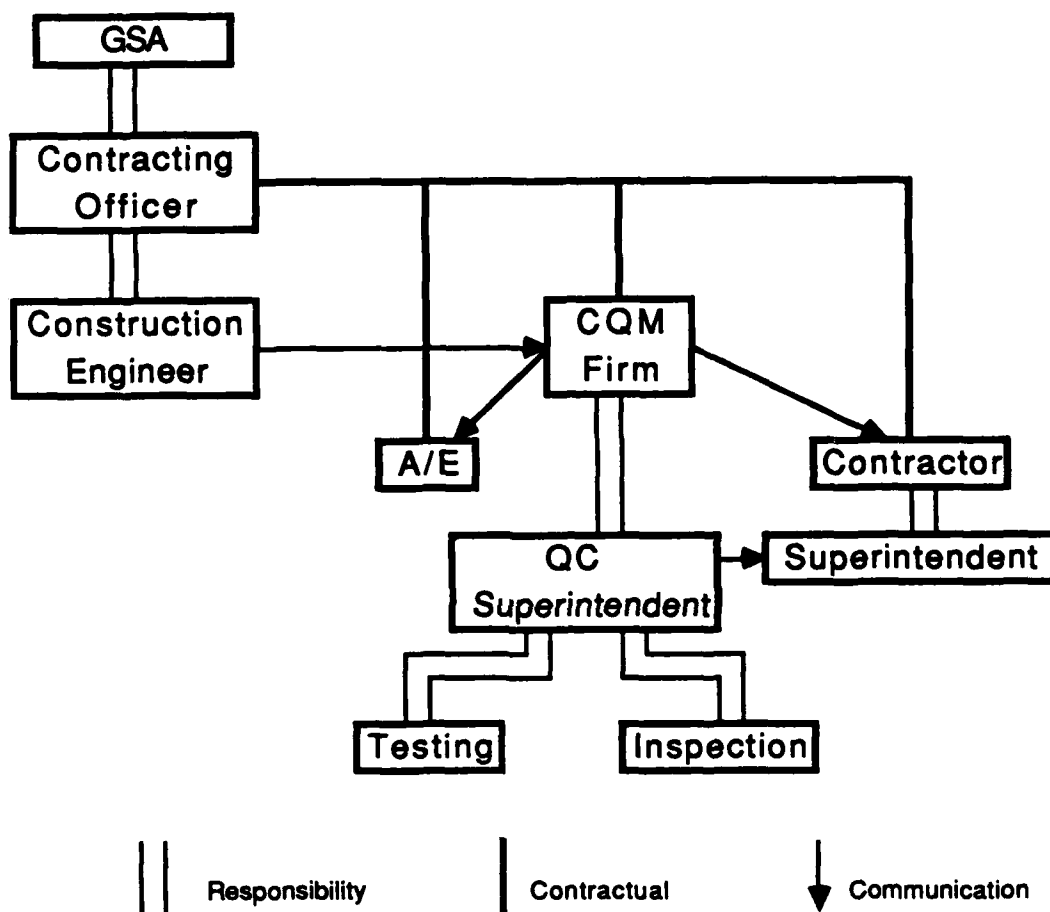


Figure 3.2 GSA CQM Project Organization.

The CQM firm can have no ties to the contractor. In fact, the GSA believes such an association is an "organizational conflict of interest" as defined in subpart 9.5 of the Federal Acquisition Regulation (14). The CQM contract prohibits the CQM firm from any ties to A/E or contractor, including as a consultant or subcontractor (14). Besides the regulation, GSA contract administrators feel the CQC approach is inappropriate for low-bid, lump-sum government projects (27 & 31).

CQM Services

During the construction phase, the CQM firm's duties include; inspect the contractor's work, notify the contracting officer and contractor of any problems, provide all testing services and results, manage submittals, monitor the contractor's safety program, administer changes, attend meetings and conferences, maintain job site records, keep a daily diary and submit weekly reports, review requests for payment, review contractor's CPM schedule, provide surveys and photographs, maintain as-built status on drawings and enforce labor standards. It may sound as though the CQM firm has complete control of the project, but it cannot direct the contractor, and must go to the construction engineer or contracting officer for most decisions (14).

CQM Contracts and Award

Regional offices award CQM contracts based primarily on technical qualifications, especially past performance, as well as preliminary management plans, management approach, personnel, experience on similar projects, and capabilities. Price is considered second (14 & 31).

Like CQC, there are two versions of CQM. The full version is used for projects over \$10 million. Like the Navy, the GSA realizes that smaller projects do not require the same degree of control. There is a simplified version of CQM for projects under \$10 million, which is a one-year term contract. The Government has the option to extend it for two additional one-year terms. For increased efficiency the GSA often combines smaller projects under these CQM contracts (31).

There are several advantages to CQM over hiring the design A/E to assist the construction engineer. The design A/Es often hire short-term inspectors who were not involved in or familiar with the project design. Since the CQM firm did not design the project, it does not hesitate to point out design errors or omissions. The CQM firms also provide a broader range of services and often have better construction expertise (31). About the only disadvantage of the CQM approach mentioned by the GSA is

that it requires a separate contract. They are reducing that inconvenience by combining CQM contracts as mentioned above.

Regional Inspection Team

In addition to CQM, the GSA's National Capital Region (which managed the Liberty Loan Building project) has another level of quality management. While unique to this region, it is an interesting quality management technique. The National Capital Region has an independent inspection team made up of specialists that visit and inspect each project. It came about during the Government building boom of the 1960s because the National Capital Region had (and still has) more construction than any other region (27).

All projects are inspected at 100% completion and those over \$2 million are also inspected at 50%. The team inspects projects over \$5 million at regular intervals (25%, 50%, 75% & 100% completion). The team includes inspectors specialized in mechanical, electrical, elevator, structural and fire prevention systems (27).

The inspection team passes its list of defects and omissions directly to the project construction engineer, who is responsible for seeing that they are corrected. He gives the contractor a copy of the list to begin corrections. During subsequent inspections, the team will first check that all earlier deficiencies have actually

been corrected. After the final inspection the construction engineer must certify that the contractor has indeed corrected all items noted by the inspection team, as well as his own inspectors (27).

These teams have good continuity because they include only experienced GSA architects and engineers. Since they inspect one project after another, they know what they are looking for and spot problems quickly. These teams are independent of construction sections so they have no loyalty to particular projects (27).

Chapter 4

RESEARCH METHODS USED

Introduction

This explanation of my research methods refers to the four objectives defined in Chapter 1. The first objective, to define the Army, Navy and GSA quality control systems, was straightforward. Officials from the Air Force, Army, Navy and GSA, involved in construction quality control, described their systems and provided the regulations, manuals, etc., that defined them. The same officials also reviewed Chapters 2 and 3 to ensure their correctness.

For the second objective, the owning agencies, design/construction agencies, maintainers and users of actual projects, defined quality requirements through a series of questions developed for each group (see Appendix B). This required choosing actual case study projects.

The third objective, comparing the success of the two quality control systems, also required case study projects. Practicalities of time and travel distance limited the number of projects to four, two from each system. I was able to study the four projects in more detail than would have been possible with many. A system for numerically rating the construction quality of each project, in several different ways, provides a basis for

comparison. The projects are also rated according to my personal judgment, and more traditional indicators of quality; cost overrun, schedule overrun, and number of modifications.

Based on the results of objective 3, I have combined the most successful elements of each construction quality control system, with recommendations for improvements in other project phases, to form a model quality management system for Air Force construction projects.

Case Study Project Selection Criteria

No interviews or reviews of records could begin before selecting the case study projects. Besides choosing an equal number of projects from each quality management system, several other criteria were used. To make the comparisons valid, the military and GSA projects had to be as similar as possible in terms of type of facility and project cost. In order to observe each quality management system in action, one project under construction was selected from each system. The other project from each system provided a complete project record.

Since this thesis is written from an Air Force perspective, the two military projects are both Air Force facilities. The Army Corps of Engineers managed the design and construction of one, the Naval Facilities Engineering Command the other. Based on a typical Air

Force construction project of \$3.36 million, projects were selected from a range of \$1-5 million.

Since the great majority of GSA projects are administrative facilities, I began with a list of forty Air Force projects involving administrative facilities. After excluding those that had not begun construction or were outside the cost range, fourteen remained. The final two were chosen based on percent complete, travel distance, and availability of project records.

The GSA's new construction program has been cut back sharply in recent years. In fact, the GSA has begun a trend of buying or leasing existing buildings to save money. As a result, the choices of GSA case study projects were much more limited. Only eleven projects were within practical travel distance. Of those, most were either far above the cost range criteria or too unique for valid comparison (e.g. the President's Guest House). The two projects selected were virtually the only ones fitting all criteria.

Data Collection

Interviews

It is my personal experience that people are more open and candid answering questions face-to-face than in writing or by telephone. Travel to the construction

agency offices to review the records of each project, made personal interviews possible. At each project, I interviewed representatives of each group mentioned above (owning agencies, design/construction agencies, maintainers and users), except for users of the projects under construction.

Interview Questions

The complete interview questionnaire is shown in Appendix B. The first five questions are for representatives of owning and design/construction agencies. The first question asks for their personal definition of construction quality as an attempt to provide additional criteria for evaluating the quality of the case study projects.

Questions 2 through 4 are designed to show which portions of the work, and their associated problems, these agency representatives value as important to quality. Question 5 asks about any weak spots in the agency's QC system, which were investigated in the case study projects.

The next two questions are for representatives of owning agencies only. Question 6 asks about the relationship, if any, between additive change orders and quality problems. This question was raised by the National Research Council study cited in Chapter 1. Similarly, question 7 asks about the relationship, if any,

between schedule overruns and quality problems.

Questions 8 and 9 are intended to reveal latent construction quality problems uncovered by maintainers and users of the case study projects.

In addition to the interviews, several other types of data were collected for each case study project.

Case Study Projects

Answers to the interview questions helped fill in the methodology framework; how the projects would be judged. A large volume of other information was collected at each project to make the judgments possible. This information included such general items as; the project description and location, original contract cost, original contract time length, type of quality management system, number and cost of contract modifications, and any time extensions.

The bulk of the data collected came from each project's records, which were studied in detail. This data included; project drawings and specifications (including quality control requirements), modifications and their justifications, correspondence, construction meeting minutes, payment records, test results, and most importantly, all inspection (QC & QA) records.

Each construction deficiency noted by an inspector was counted. Each deficiency falls into one of the sixteen standard construction divisions used in Federal construction specifications (see Appendix B).

Each deficiency was rated according to one of five ways it was resolved; 1) promptly, 2) slowly or after repetition, 3) disputed by the contractor, 4) accepted by the Government with a credit or 5) accepted by the Government as is. They were also rated by size; Small - no significant cost to correct or impact on overall quality, Medium - significant cost to correct and potential impact on overall quality, or Large - the cost to correct is more than the original cost of the item and has a serious impact on overall quality.

The cost of each division as a percentage of total project cost was also noted for later use in weighting the deficiency totals for comparison.

Cataloging each deficiency and reviewing the complete project record gave the author a thorough understanding of each project and its particular problems.

Chapter 5

RESULTS

Interviews

Military

Representatives of military owning and design/construction agencies tended to agree that construction quality is "building according to the requirements of the contract drawings and specifications" (see table 5.1). Fifty percent of them gave that answer to question 1, some of them emphasizing that the plans and specifications are based on the users needs. Other definitions of construction quality included "workmanship to local industry standards," "the finished product serves its intended purpose," "the contractor's personal commitment to doing a good job," "structural integrity," "performance over time" and "it all depends on design quality" (8.3 percent each).

The answers to questions 2 and 4 indicate that most military construction problems involve general requirements (42.5%), sitework (12.5%), masonry (10%), mechanical (10%), concrete and finishes (7.5% each). While in question 3, the same representatives found the following divisions most important to quality; mechanical (13.8%), thermal and moisture protection (12.3%), finishes

Table 5.1 Military Interview Results.

QUESTION 1. DEFINE CONSTRUCTION QUALITY	NUMBER	PERCENT
ACCORDING TO PLANS AND SPECIFICATIONS	6	50.0
WORKMANSHIP TO LOCAL INDUSTRY STANDARDS	1	8.3
FINISHED PRODUCT SERVES INTENDED PURPOSE	1	8.3
CONTRACTOR'S COMMITMENT TO DOING A GOOD JOB	1	8.3
STRUCTURAL INTEGRITY	1	8.3
PERFORMANCE OVER TIME	1	8.3
DEPENDENT ON DESIGN QUALITY	1	8.3
TOTALS	12	100.0

QUESTIONS 2 AND 4. CONST. QUALITY PROBLEMS			QUESTION 3. IMPORTANT DIVISIONS		PERCENT OF VALUE FOR SCORE SHEETS	
DIVISION	NUMBER	PERCENT	NUMBER	PERCENT	SUM	% OF SUM
1	17	42.5	6	9.2	23	21.9
2	5	12.5	3	4.6	8	7.6
3	3	7.5	7	10.8	10	9.5
4	4	10.0	6	9.2	10	9.5
5	1	2.5	3	4.6	4	3.8
6	0	0.0	2	3.1	2	1.9
7	0	0.0	8	12.3	8	7.6
8	1	2.5	4	6.2	5	4.8
9	3	7.5	8	12.3	11	10.5
10	0	0.0	1	1.5	1	1.0
11	0	0.0	2	3.1	2	1.9
12	0	0.0	0	0.0	0	0.0
13	0	0.0	1	1.5	1	1.0
14	0	0.0	0	0.0	0	0.0
15	4	10.0	9	13.8	13	12.4
16	2	5.0	5	7.7	7	6.7
TOTALS	40	100.0	65	100.0	105	100.0

QUESTION 5. DEFICIENCIES OVERLOOKED?		
	NUMBER	PERCENT
YES	5	41.7
NO	7	58.3
TOTALS	12	100.0

QUESTION 6 RELATIONSHIP? CHANGE ORDERS & QUALITY			QUESTION 7. RELATIONSHIP? SCHEDULE OVERRUNS & QUALITY		
	NUMBER	PERCENT		NUMBER	PERCENT
YES	2	50.0	YES	3	75
NO	2	50.0	NO	1	25
TOTALS	4	100.0	TOTALS	4	100

(12.3%), concrete (10.8%), general requirements and masonry (9.2% each).

Most military representatives (58.3%) did not feel the CQC systems tended to overlook any specific types of quality deficiencies, but 41.6% did. Representative comments from the majority included, "The level of enforcement depends on the contractor's track record.", and "It depends on the character of the QC individual." Areas overlooked in the opinions of the minority include enforcement of CQC ("But the new (Navy) spec. is better, preparatory inspections will help prevent problems otherwise caught too late."), outdated concrete, masonry, flashing and mechanical specifications, concrete, mechanical, roofs, finishes ("occupants expect more"), preservative treated lumber ("too easy to cheat") and equipment.

Answers were evenly split between those who saw a relationship between additive changes and quality problems, and those who did not. A member of the first group pointed out that change orders demand much of a contract administrator's time, leaving that much less for QA. Most who saw no relationship felt that changes have more to do with design errors and omissions. No one mentioned the possibility that modifications might be used as a way to correct quality deficiencies.

There was more agreement (75%) that schedule overruns and quality problems are related. Those agreeing

commented that design problems cause many contract modifications which lead to schedule delays. Again, administering the modifications takes time away from QC and QA. They also felt that contractors trying to catch up pay less attention to quality. Others (25%) felt that unrealistic schedules and contract administration problems have more to do with delays.

Military facility maintainers mentioned several construction problems they encounter. A serious problem, in their view, is that project managers frequently try to reduce construction costs by deleting important maintenance-related elements of facilities, such as back-up pumps and generators, from the design. The same items are then ordered with different funds, but often arrive after project completion.

Other problems they encounter are concealed sloppy ductwork and plumbing, and badly patched concrete finishes.

Complaints from the users of the completed military construction project (Comptroller Services Center) included; the ceiling had been placed too low which required some tiles to slope up to the tops of window frames, some ceiling damage from sweating or leaking chilled water pipes, and continuous failure of door hardware. The users listed several other design-related problems.

GSA

As with the military, fifty percent of the GSA representatives defined construction quality as "built according to contract plans and specifications" (see Table 5.2). One third answered "meeting industry standards of workmanship." The remainder (16.7%) said construction quality is equivalent to a "contractor's pride in his work."

GSA representatives encountered most construction problems in mechanical (25.8%), finishes (22.6%), general requirements, concrete and electrical divisions (all 9.7%). The divisions they found most important to quality are concrete, doors and windows, finishes, mechanical and electrical (all 13.6%).

Two-thirds agreed that specific problems are being overlooked by their quality control system. Problems they mentioned include a lack of enough inspectors, structural systems, roofing ("because the industry is changing from built-up to membrane"), painting and sheetmetal ("no one understands the requirements . . . so contracts require higher standards to be safe"). The other third agreed that there is a lack of expertise in some areas, but that is improving now that design and inspection are mostly contracted out.

Only one of four GSA representatives saw a connection between additive change orders and quality problems. One

Table 5.2 GSA Interview Results.

QUESTION 1. DEFINE CONSTRUCTION QUALITY	NUMBER	PERCENT
ACCORDING TO PLANS AND SPECIFICATIONS	3	50.0
WORKMANSHIP TO LOCAL INDUSTRY STANDARDS	2	33.3
CONTRACTOR'S PRIDE IN HIS WORK	1	16.7
TOTALS	6	100.0

QUESTIONS 2 AND 4. CONST. QUALITY PROBLEMS			QUESTION 3. IMPORTANT DIVISIONS		PERCENT OF VALUE FOR SCORE SHEETS	
DIVISION	NUMBER	PERCENT	NUMBER	PERCENT	SUM	% OF SUM
1	3	9.7	0	0.0	3	5.7
2	2	6.5	2	9.1	4	7.5
3	3	9.7	3	13.6	6	11.3
4	0	0.0	1	4.5	1	1.9
5	1	3.2	1	4.5	2	3.8
6	0	0.0	2	9.1	2	3.8
7	3	9.7	1	4.5	4	7.5
8	0	0.0	3	13.6	3	5.7
9	7	22.6	3	13.6	10	18.9
10	0	0.0	0	0.0	0	0.0
11	0	0.0	0	0.0	0	0.0
12	0	0.0	0	0.0	0	0.0
13	0	0.0	0	0.0	0	0.0
14	1	3.2	0	0.0	1	1.9
15	8	25.8	3	13.6	11	20.8
16	3	9.7	3	13.6	6	11.3
TOTALS	31	100.0	22	100.0	53	100.0

QUESTION 5. DEFICIENCIES OVERLOOKED?		
	NUMBER	PERCENT
YES	4	66.7
NO	2	33.3
TOTALS	6	100.0

QUESTION 6. RELATIONSHIP? CHANGE ORDERS & QUALITY			QUESTION 7. RELATIONSHIP? SCHEDULE OVERRUNS & QUALITY		
	NUMBER	PERCENT		NUMBER	PERCENT
YES	1	25.0	YES	2	50.0
NO	3	75.0	NO	2	50.0
TOTALS	4	100.0	TOTALS	4	100.0

of the other three said, "Sometimes you get better quality with changes because they're negotiated." The same four were evenly split as to whether schedule overruns are related to quality problems. One noted that if a contractor is not very proficient he is bound to have both schedule and quality problems. Another agreed that while quality contractors are usually on time, and problem contractors are often late, the contractor's quality and schedule performance are not necessarily related.

GSA facility maintainers, like their military counterparts, expressed frustration with "maintenance provisions being sacrificed when other items are added to the design or money is tight." They mentioned several other problems, mostly mechanical; equipment without proper vibration control causing stress cracks in floors, construction dust and debris getting into unfiltered mechanical equipment which is run during construction, and mechanical operations and technical manuals not finding their way to the maintenance people at job completion. They frequently encounter roof problems. The GSA maintainers are also frustrated with the deficiencies in commercial buildings the GSA buys. They claim they are built to lower standards than the GSA requires for new construction.

The users of the completed GSA construction project listed only relatively minor problems. The flat latex interior finish had to be repainted in less than two

years, some windows are opened and closed so many times a day they wore out prematurely, a few ceramic floor tiles came loose, and there is some surface cracking of concrete finishes. Like the Air Force users, the majority of their complaints reflected design rather than construction problems.

Deficiency Ratings

There are four types of deficiency ratings for each project 1) based on deficiency resolution and project cost, 2) based on deficiency size and project cost, 3) based on deficiency resolution and the design/construction agency's values and 4) based on deficiency size and the design/construction agency's values (see Appendix D).

Chapter 6

ANALYSIS AND DISCUSSION

Comparison of Military and GSA Interviews

Defining Construction Quality

By far the most common definition of construction quality from both sides was "built according to contract plans and specifications". Representatives from both the military and GSA qualified this definition by stressing that overall quality depends on how well the plans and specifications interpret the users real needs. In fact, the Army Chief of Engineers, in a recent policy letter emphasizing quality, defined it as "conformance to properly developed requirements" (7). He went on to say that before quality can apply to construction, it begins with "requirements carefully developed by our customer, reviewed for adherence to existing guidance, and ultimately reflected in criteria and design documents which accurately address these needs" (7). This definition agrees with the contractual interpretation of construction quality.

Both agencies also mentioned workmanship, and the contractor's commitment or pride in his work, in their definitions. Several inspectors complained that many specifications are not written clearly enough to establish an acceptable level of craftsmanship.

Agency Quality Values

Table 6.1 summarizes the answers to questions 2, 3, and 4.

Table 6.1 The Divisions Military and GSA
Owning and Design / Construction Agencies
Find Most Important to Quality

<u>DIVISION</u>	<u>MILITARY</u>	<u>GSA</u>
1. General Requirements	21.9*	5.7*
2. Sitework	7.6	7.5
3. Concrete	9.5	11.3
4. Masonry	9.5	1.9
5. Metals	3.8	3.8
6. Wood and Plastics	1.9	3.8
7. Thermal and Moisture Protection	7.6	7.5
8. Doors and Windows	4.8	5.7
9. Finishes	10.5	18.9
10. Specialties	1	0
11. Equipment	1.9	0
12. Furnishings	0	0
13. Special Construction	1	0
14. Conveying Systems	0	1.9
15. Mechanical	12.4	20.8
16. Electrical	6.7	11.3

* Indicates value to agency as a percentage of overall quality.

There is general agreement on which divisions are the most important to overall quality, with some notable exceptions. The military feels that the General Requirements division, which includes CQC requirements, is by far the most important. For example, many of the quality problems they listed involved QC enforcement, submittals procedures, prime contractor coordination of subs and omitting required tests. Also, by using preparatory inspections, the military emphasizes General

Requirements items before they become associated with a particular segment of work.

The military emphasis on the Masonry division probably has more to do with the fact that the two military projects were predominately masonry construction, than with a difference in values between the two agencies.

The GSA places more importance on finishes. GSA facilities are occupied by other Federal agencies and are more often public, requiring higher standards for finishes.

Finally, the GSA representatives felt that the Electrical, and especially the Mechanical divisions, are very important to overall project quality. Mechanical and electrical problems, such as improper equipment sizing, air and water systems not correctly balanced, and malfunctioning fire alarm systems, were mentioned more often in GSA interviews. The GSA also seems to stress the inspections of mechanical and electrical divisions more than the military. This emphasis is due to the GSA's responsibility for maintaining, as well as constructing, Federal facilities.

Weak Spots and Trends

There was no clear consensus from either agency on whether certain quality deficiencies were being overlooked. One common comment from both sides was that the fewer inspectors you have, the more limited you are by

their weaknesses. Both groups would like to have more Government inspectors. One military QA representative complained that the QC representative spent so much of his time with submittals and changes, that his QA inspections included a lot of QC work.

Similarly, no clear trends emerged from the answers to questions 6 and 7. One can't argue with the observation that the more cost and time changes a project has, the less time QC and QA personnel have available to spend on quality.

Military and GSA maintenance personnel comments were quite similar. Both complained of project designers and managers overlooking life-cycle maintenance costs to save a few dollars on construction costs. They also felt that designers often ignore simple maintenance needs (such as a place to store snow blowers at the Houlton, Maine, Border Station).

The majority of complaints from the users of both completed projects dealt with design, rather than construction problems.

A good example of how the two can be related occurred at the Comptroller Services Center Project. The contractor submitted literature on some air handlers he proposed to use above the suspended ceiling. The project engineer approved the contractor's submittal. When the time came to install the air handlers it was obvious that the contractor had placed the ceiling about ten inches too

high, and they would not fit. After checking more closely it was also clear that the air handlers would not have fit above the ceiling as originally designed. Ironically, there was a type of air handler that would have fit, but since the contractor's submittal was approved, the Government had to pay the cost of lowering the ceiling.

Comments on CQC

In addition to answering the interview questions, many of the military representatives made observations about the CQC system. Several agreed that if the contractor uses the CQC system properly, it will save him costs by catching problems before rework is necessary. For example, on the Wing Headquarters project, the QC representative did not notice that a masonry curtain wall was not flush with the lintel supporting it. When the QA representative discovered it many courses later, it had to be torn out and redone.

One QA representative felt that the CQC system was excellent in general as long as the QC people were qualified, experienced, and had some scruples. But he advocated full-time QA on every job, no matter how small, for coordination, and because he finds as many problems as the QC representative uncovers. Like several other military representatives, he shares the assertion that QC personnel are spending too much time on submittals, expediting materials, and coordinating subs. Either the

QA representative ends up covering for the QC representative, or QC suffers.

Most military representatives would rather have their own people doing QA, although they had no serious complaints about Title II. One officer said the Title II firms' only weakness was their unfamiliarity with Government regulations and paperwork. The apparent resistance to Title II in some areas seemed to be mostly a matter of pride.

Contractor Comments

The author had the opportunity to speak with the contractors on the projects under construction. The contractor on the Comptroller Services Center had no previous experience with CQC, but said the requirements of a local school district, and another project under a construction management firm, were similar. He took the CQC requirements seriously when bidding, and was not surprised when they were enforced. He was surprised by the requirements for an alternate QC representative and submittals clerk, contained in the new version of the CQC specification. He says CQC saves him money, not only by preventing costly rework, but also because he can reduce his central office overhead and project administration costs. This tends to confirm claims by QA personnel that QC representatives are performing some of the superintendent's tasks.

The contractor working on the Liberty Loan Building for the GSA also had experience on CQC jobs for the Army. He had performed renovations at the Library of Congress and the Smithsonian, and has a good relationship with the GSA. GSA representatives consider him a quality contractor. He said, "The GSA only requires paperwork as needed, like pile logs, test reports, submittals and certified welds. They use common sense." He found CQC frustrating because his paperwork did not satisfy the Corps of Engineers, although they had no quarrel with the quality of his work. He felt their focus was too narrow. This contractor plans to bid again on jobs requiring CQC, but he will add to his bid to cover the extra personnel, administrative, and testing costs.

Case Study Projects

Military

Comptroller Services Center. This project has the best scores for all four deficiency ratings (see table 6.2). Its original-to-final cost and time ratios are quite small as are the total number of contract modifications.

While this project may have had the best construction quality, my subjective impression is that it did not quite have the best overall quality. This is due to many design and administrative problems apparent throughout the

Table 6.2 Overall Score Compilation.

	MILITARY				GSA			
	COMPTROLLER SERVICES CENTER		WING HEADQUARTERS		LIBERTY LOAN BUILDING		BORDER STATION	
	SCORE	RATING	SCORE	RATING	SCORE	RATING	SCORE	RATING
SCORE SHEET #1	708.1	1	721.4	2	1256.3	3	4581.7	4
SCORE SHEET #2	711	1	767.5	2	1199.3	3	2664.3	4
SCORE SHEET #3	484.7	1	669.5	2	977.5	3	4201.1	4
SCORE SHEET #4	471.4	1	733	2	966.3	3	2450.2	4
FINAL/ORIGINAL COST	3.2%+	2	3%+	1	27%+	4	11.4%+	3
FINAL/ORIGINAL TIME	14.8%+	1	20%+	2	20%+	3	22.6%+	4
NUMBER OF CHANGES	13	2	9	1	54	3	80	4
SUBJECTIVE RANKING		2		1		3		4

project records, such as the ceiling problems mentioned earlier.

In another example from the same project, an Air Force project manager at a headquarters level chose an exterior panel color based on a staff architect's recommendation. The color was not at all what the local officials had requested to fit in with their overall base color scheme. No one noticed the difference until the contractor delivered the panels. Project managers explored several options, including reordering or repainting the panels, but all were judged too expensive and the wrong color remains. The source of this problem was in the many different geographically separated offices and agencies involved, and their communication difficulties, but it had a serious impact on project quality.

Wing Headquarters. This project ranks second in all deficiency ratings, close behind the Comptroller Services Center. Its original-to-final cost ratio and number of modifications are slightly better. The original-to-final time ratio is moderate.

Both the Navy's and contractor's project organizations impressed me. QA was by a full-time Title II A/E, yet the Resident Officer in Charge, despite his very small staff, was completely up to date and involved in the project's daily progress. The contractor's

paperwork was complete and he seemed to be following all the CQC procedures. Both the contractor and his QC representative (a retired Air Force engineer) appeared conscientious and sincere in their performance of CQC. The only serious CQC problem noticed was submittals taking up QC time as mentioned above.

GSA

Liberty Loan Building. This project received moderate ratings in most areas. Its deficiency ratings are third overall, but much better than the worst project. The original-to-final time ratio and the number of modifications are not especially good, but the original-to-final cost ratio is by far the worst. This is due to major user-requested changes made after contract award. Despite their size (over \$1,000,000) the cost of these changes has been included since they did not constitute a change in scope, and did not directly affect the project's score sheet rankings.

The GSA project engineer, the A/E inspector, and the contractor's people all seemed to have a good working relationship. The contractor has a reputation for quality in the GSA's National Capital Region. The major impact on quality was that the dozens of user-requested changes took so much time and attention away from quality management. Everyone involved was working hard to keep up with all the changes and quality suffered. The Regional Inspection

Team inspected the project at thirty and fifty percent completion. This helped control construction quality by providing a fresh set of eyes and catching many deficiencies while they were still correctable.

Border Station. The deficiency ratings for this project are by far the worst. Although the original-to-final cost ratio is less than half that of the Liberty Loan Building, the original-to-final time ratio and number of modifications are the worst of all.

At first there was only an inspector from the design A/E firm on site. There were quality problems from the beginning and a full-time GSA inspector soon arrived. Both inspectors watched the project closely and kept thorough records. Although they pointed out discrepancies to the contractor daily, they were often ineffective.

This was due to the site's remote location. The project architect and the GSA Contracting Officer's Representative only visited the site every two weeks for construction meetings. When the on-site inspectors pointed out deficiencies to the contractor that were expensive to correct or that he did not agree with, he would ignore them until the next construction meeting. By then many of the discrepancies had been built over and would have been even more costly to correct. The Contracting Officer's Representative had to decide whether

to insist on expensive corrections or accept poor quality work.

He compromised by requiring corrections of those deficiencies he judged serious while accepting others, some with a credit. This made the contractor mad because of the increased rework costs (even though he could have corrected the deficiencies earlier), and alienated the on-site inspectors who felt their authority had been undermined. A strong adversarial relationship evolved between the contractor and the GSA, further damaging quality management.

Many of these items remained unresolved when construction was completed, which, along with weather delays, added to the overall project time.

The remote site is not a valid excuse for this project's quality problems. By comparison, the Navy's Resident Officer in Charge of Construction at the Wing Headquarters project had a staff of only two and was supported by an office over 150 miles away.

Summary

By all methods of measurement, both military projects achieved much better construction quality than the two GSA projects. The fact that they both scored so much better, with scores that are so close, indicates a consistent application of their common quality management system.

I attributes this success chiefly to two factors: preventative inspections and strict QA procedures.

The most important key to the CQC system's success is its emphasis on preventing, rather than detecting, mistakes. The three phases of inspection recently incorporated into the Army and Navy CQC systems make this possible. The preparatory inspection keeps the contractor from beginning a segment of work before he can show that submittals, materials, preliminary work, procedures, safety and tests are all right and ready to go. In this way many of the most serious deficiencies are corrected before they can happen. Likewise, the initial inspection makes sure the work is being done properly while it's early enough to make corrections. The three phase system also allows limited QA staffs to prioritize their inspections by emphasizing the first two.

The military has always been notorious for regulations and paperwork. In these projects at least, the CQC requirements seem to have paid off. The Army and Navy used the numerous forms and reports as intended. They helped ensure that the Government and contractors followed QC and QA procedures consistently. The contractors did not appear overburdened with paperwork in either project.

The most successful element of quality management seen in the two GSA projects was the Regional Inspection

Team. Its value is in putting an independent team of experienced experts on the site to spot deficiencies during construction. Their experience enables them to do that efficiently, so they can quickly move on to the next project.

Chapter 7

A MODEL QUALITY MANAGEMENT SYSTEM FOR AIR FORCE PROJECTS

The Success of CQC

Since this thesis is limited to only four case study projects, which supported the success of CQC versus a more traditional QC system, it has little basis to suggest change.

The most serious weakness revealed by the case study projects, the tendency of QC personnel to spend too much time on submittals, is corrected by the Navy's new requirement for a submittals assistant as part of the CQC staff. The Army should adopt the same requirement.

In both CQC projects the contractor's CQC representatives were not organizationally separate from the project superintendent or manager. This raised the question of a conflict of interest, but did not seem to be a problem in the projects studied. It can be argued that if the contractor is responsible for his own quality, CQC should be integrated with his construction operations. This is consistent with the Japanese approach to quality, attracting so much attention lately, in which each worker is responsible for his contribution to project quality. The Army and Navy should consider encouraging contractors to integrate their CQC and construction operations. If

adopted, this approach would make the proper training of Government QA representatives even more important.

Many commented during interviews that the CQC system is only as good as a particular project's contractor. This is true of any quality management system. In fact, CQC acknowledges quality's dependence on the contractor by giving him additional responsibility. While many involved with CQC believe it presents the contractor with a conflict of interest, this research found no evidence of contractor cheating.

The most successful element of the GSA quality management system, the Regional Inspection Team, already exists, to some degree, in the Air Force. Teams with representatives from Air Force Engineering and Services Headquarters (LEEE), Air Force Regional Civil Engineering (AFRCE) offices, and major command headquarters (MAJCOM), periodically inspect some projects after completion. However, "because other priorities are more pressing," most AFRCEs seldom conduct post occupancy inspections (24). An official at one AFRCE only remembers one such inspection in the last fourteen years (23).

Greater Impacts on Project Quality

This thesis studies two systems of managing quality during construction, and their impact on overall project quality. My interest, from an Air Force perspective, has been finding ways to improve the military's quality

management system. Based on the limited number of projects studied in this work, the military's construction quality control system is functioning relatively well. Well enough in fact, that problems in design and the design / construction interface have a greater impact on overall project quality.

Sources of Quality Problems

From personal experience and observation of the case study projects, several situations combine to adversely impact overall quality. Most of these situations occur before the construction phase.

There are many unavoidable reasons for change in military construction projects. The time between programming and construction completion is at least five years and often more. During this period there can be changes in; the user's mission or needs, the user itself, design policy, the base mission, commanders and project management. Such changes almost always lead to design and construction changes, which may add cost and time to the project. After completion, the typical Air Force facility undergoes several changes in use during its life-cycle.

Many of the problems that surfaced during construction could and should have been caught during design reviews. Drawings submitted by A/E firms are often uncoordinated. Because of manpower and time limitations, design reviews by military agencies are usually cursory.

Programming, design, bidding, award, construction and evaluation are all phases in one continuous process. The organization of some military engineering agencies does not reflect this continuity. Many military projects are literally "handed off" from design to construction sections. This creates an artificial point of discontinuity in the process. The design section is usually too busy with new projects to adequately brief the construction section. The construction people are not familiar with and were not involved in the design.

In my experience, personnel in both the design and construction sections usually have design backgrounds. The people in construction are assigned projects that have entered the construction phase. Because of this artificial separation between design and construction sections, constructability reviews tend to be design reviews after design completion. A planned constructability program should include construction expertise during all phases of a project. It reduces project costs and schedules by analyzing; the optimum sequence of drawing and detail preparation, labor intensive operations, available construction technology, opportunities for shop fabrication and preassembly, optimum site layout and cost impact of design changes (1).

Aside from the traditional and incomplete methods of cost and time performance, the Air Force has no system of tracking quality through all project phases. Air Force

officials seemed only vaguely aware that post occupancy inspection reports and contractor evaluations are currently available from the Army and Navy.

As mentioned above, an Air Force program of post occupancy inspections exists on paper, but is seldom performed.

Finally, when serious quality problems do occur in military construction, no one is usually held accountable. The anonymity of military engineering agencies and the frequency with which their personnel are reassigned makes accountability difficult. This hasn't stopped Lt. Gen. E.R. Heiberg III, Army Chief of Engineers. He has directed that "performance standards for all management and technical personnel involved directly in the design or construction management process clearly include quality management as a critical element of performance" (7).

Recommendations

Within the context of developing a model quality management system, there are a number of improvements the Air Force can make in the areas of design, the design / construction interface, and construction:

1. Flexibility. The Air Force should recognize that a certain amount of change is unavoidable and require designs that can more easily accommodate changes in use.

2. Design Review. Design firms should be required to coordinate their own and their consultants' designs. The Air Force must remind its own architects and engineers that a little time invested in careful design review can save many costly and time-consuming problems later.
3. Design/Construction Interface. The cradle-to-grave project management approach, begun in some AFRCEs a few years ago, should be adopted Air Force wide, including MAJCOMs. If this is not possible, design and construction engineers must overlap their involvement to prevent discontinuity in the process.
4. Constructibility Input. The Air Force should expand its new program of awarding design/build contracts when possible. This form of contract involves the construction contractor in the earliest phases of design. It also provides a more current project definition for design (5). For standard lump-sum contracts, the Air Force should consider hiring leading contractors to conduct constructability programs. The Air Force could benefit from their construction expertise in much the same way that it uses value engineering for independent design reviews. This is another opportunity in the process to improve the design, reduce cost, and prevent problems before they occur.

5. Tracking Project Quality. A system to rate project quality would be valuable in evaluating designer and contractor performance, in defining acceptable and unacceptable ranges of quality, and in spotting trends and problems geographically or by facility type. The system used to compare construction quality in this thesis is proposed as a beginning step.
6. Post Occupancy Inspections. This program should be revitalized and included in an overall program of tracking project quality. Post occupancy inspections would provide feedback on design adequacy, contractor performance, work required before warranty expiration and preventing maintenance through better design. Again, time invested in these inspections would prevent reoccurrence of the problems discovered.
7. Accountability. Accountability for failures and recognition of successes should not be overlooked as methods of improving overall project quality. The Air Force design awards program has been successful in this area. The Air Force should also consider measures similar to those Lt. Gen. Heiberg directed.

Chapter 8

CONCLUSION

Thesis Summary

The original objective of this thesis was to develop a model quality management system for Air Force construction projects. There were three major steps toward reaching this objective.

The existing quality management systems in use were first defined. This was a relatively straightforward process of reading documents and interviewing agency officials.

The next step, defining quality requirements, was much more difficult. Through interviews I found most frequent definition in all agencies was conformance with contract requirements, based on the user's needs. The system for scoring project quality is based on this definition by counting the number of items that did not meet contract requirements. The scoring system indirectly includes other definitions by weighting scores according to agency opinions of the construction divisions most important to quality. As might be expected, scores using subjective agency values were consistently better than those using objective percentage-of-cost weightings.

The third step was developing a system for measuring and comparing the quality of each project, based on the above

definition. The intention of the four different score sheets was to include as many potential valid measures of quality as possible. Deficiencies were not only counted, they were weighted according to size, eventual resolution, construction division, percent of cost and agency value. I had expected to compare the scores with my subjective rankings, and traditional indicators, of each project's quality to find which scoring criteria gave the best correlation. Suprisingly though, each score sheet gave the same relative quality rankings to each project. They also correlated very closely with my subjective rankings and the traditional indicators. This shows that relatively unsophisticated quality assessment systems can consistently rank construction project quality levels. Agencies that use the lack of a common definition of quality as an excuse for not trying to measure it should consider these results.

The thesis focused on the construction quality control system. The case studies showed this system, while not perfect, to be working relatively well. In fact, the majority of deficiencies and problems noted were not construction problems. This is one reason I felt the need to address problems in design and the design / construction interface that affect project quality.

The other reason is the tendency I observed of agencies to treat design and construction as separate, self-contained project phases. While this approach allows

for specialization, it creates barriers to continuity, communication, and constructibility programs. However a project is organized, programming, design, bidding, award, construction and evaluation are just successive phases in a continuous process. The model I originally intended ignored the phases before construction. Once I saw where the greatest potential for improving overall project quality lie, it became obvious that a quality management system must address all project phases.

Implementing the Model Air Force Quality Management System

The proposed model does not advocate significant change in the current CQC system. Through the problems identified, and recommendations made in Chapter 8, it attempts to expand the Air Force's quality management system to all project phases. It advocates taking a comprehensive approach to project quality management.

Topics for Further Research

The following research topics would help validate this work or take it further:

- Validate this work based on a larger number of case studies.
- Study additional GSA projects once their new CQM system is operating.

- Specifically examine evidence of contractor conflict of interest in CQC.
- Further develop techniques for assessing project quality in all phases.
- Improve design reviews in military construction projects.
- Implement constructability programs in military construction projects.
- Quantify benefits of post occupancy inspections.
- Compare quality management programs in other Federal agencies with large construction programs, such as the Veterans Administration or the Department of Energy.
- Examine the pros and cons of standardizing design and construction procedures within the Federal Government.
- Consider the application of Japanese style total quality management to a contractor's CQC program.

Intent of the Work

It is not my intention to tell Federal design and construction agencies how good a job they are doing or that they need to change their systems. That would obviously be presumptuous. I have made a sincere effort to find opportunities for improvement, and to point them out. I have not seen other attempts to develop a rating system for construction quality, and offer this attempt hoping it will generate further interest and

investigation. If not completely convincing, the recommendations should at least promote discussion and awareness of problems. Finally, other researchers and the agencies involved will hopefully pursue the suggested topics for further research.

APPENDIX A
CASE STUDY PROJECTS

MilitaryComptroller Services Center, Pope AFB, NC

Description: A two-story slab-on-deck masonry and steel building. The total gross floor area is 14,029 sf. This is the financial center for the air base, housing such offices as travel pay, military pay, customer service, materiel, accounting, civilian pay, and budget.

Location: Pope Air Force Base, Fayetteville, North Carolina.

Using agency: U.S. Air Force.

Design/construction agency: U.S. Army Corps of Engineers.

Quality management: CQC under the Army's Savannah District office, with resident Area Engineer adjacent to Pope. There was a full-time QA representative, no Title II services were used. The Air Force project engineer made weekly cursory inspections.

Percent complete when studied: 100%. The project had been complete approximately two years.

Original contract amount / final contract amount: \$926,974 / \$956,787, 3.2% increase.

Original contract time / final contract time: 337 days / 387 days, 14.8% increase.

Number of modifications: 13.

Wing Headquarters, Shaw AFB, SC

Description: A three-story (two above and one below grade) steel and masonry structure. The total gross floor area is 25,485 sf. The building provides office space for the Wing Commander and his staff, such as the Deputy Commander for Operations, the Safety office and the Public Affairs office. The basement houses the base command post.

Location: Shaw Air Force Base, Sumter, South Carolina.

Using agency: U.S. Air Force.

Design/construction agency: Naval Facilities Engineering Command.

Quality management: CQC under the Navy's Southern Division office in Charleston, with a Resident Officer in Charge of Construction at Shaw. QA was supplemented with Title II services.

Percent complete when studied: 65%.

Original contract amount / final contract amount:
\$2,218,254 / \$2,288,374, 3% increase.

Original contract time / final contract time: 365 days
/ 438 days, 20% increase.

Number of modifications: 9.

GSALiberty Loan Building. Washington, DC

Description: Renovation of a five-story office building, built in 1911, for the Treasury Department. The building was completely gutted, including most interior walls. All new mechanical, electrical, lighting and fire prevention systems were installed, as well as some new drywall and masonry partitions.

Location: Washington, DC.

Using agency: U.S. Treasury Department.

Design/construction agency: General Services Administration, National Capital Region.

Quality Management: Traditional GSA approach. The construction engineer, working two other projects, was assisted by one full-time A/E inspector and secretary on site.

Percent Complete when Studied: 85%.

Original contract amount / final contract amount:
\$5,090,000 / \$6,458,538, 27% increase.

Original contract time / final contract time: 550
days / 662 days, 20% increase.

Number of modifications: 54.

Border Station, Houlton, ME

Description: Two-story steel and masonry main building with primary and secondary inspection bays, offices, and holding cells. The project also includes a one-story masonry warehouse with truck inspection bays, and a one-story masonry animal inspection building. Total gross floor area is 33,000 sf.

Location: U.S./Canadian border at the northern end of I-95, Houlton, Maine.

Using Agency: U.S. Immigration and Naturalization Service.

Design/construction agency: General Services Administration, Boston office.

Quality management: Traditional GSA approach. A full-time GSA field engineer was assisted by a full-time inspector from the design A/E firm. A GSA Contracting Officer's Representative and the A/E Project Manager made bi-monthly trips from Boston to inspect the project and attend construction meetings.

Percent complete when studied: 100%. The project had been complete approximately a year-and-a-half.

Original contract amount / final contract amount: \$2,673,000 / \$2,978,764, 11.4% increase.

Original contract time / final contract time: 350 days / 429 days, 22.6% increase.

Number of modifications: 81.

APPENDIX B
INTERVIEW QUESTIONS

For Representatives of Owning and Design/Construction Agencies (This includes contract administrators and inspectors as well as the GSA's independent regional inspection team and any Army or Navy counterparts.):

1. How do you personally define construction quality?
2. What types of quality problems do you look for?
3. Construction contracts define quality as meeting the requirements of the specifications. Which do you consider the five most important specification divisions for quality?

Ranking	Division
()	1. General Requirements including Quality Control
()	2. Site Work
()	3. Concrete
()	4. Masonry
()	5. Metals
()	6. Wood and Plastics
()	7. Thermal and Moisture Protection
()	8. Doors and Windows
()	9. Finishes
()	10. Specialties
()	11. Equipment
()	12. Furnishings
()	13. Special Construction
()	14. Conveying Systems
()	15. Mechanical
()	16. Electrical
4. Name three specific types of recurring construction quality problems you always check for.
5. What specific quality deficiencies does your agency's system of quality control tend to overlook?

For Representatives of Owning Agencies only (The regional offices of the Air Force, Army, Navy and GSA that oversee projects.) In addition to questions 1, 3 & 5 from above:

6. Describe the relationship, if any, between additive change orders and quality problems.
7. Describe the relationship, if any, between schedule overruns and quality problems.

For Maintainers (The local organizations that must operate and maintain the completed facilities.):

8. Name three problems you frequently encounter with the buildings you operate and maintain. What do you attribute them to?

For Users (The actual occupants of the facility.):

9. What problems have you noticed with the building that might be related to construction quality?

APPENDIX C
PERSONS INTERVIEWED FOR QUESTIONNAIRES

MilitaryAir Force

Gary Cox
Project Engineer
Shaw AFB, SC

Len Farnung
Chief of Engineering & Environmental Planning
Pope AFB, NC

Don Folkers
Contractor CQC Representative
Wise Construction Co.
Shaw AFB, SC

Ben Green
Construction Management Inspector
Pope AFB, NC

Ms. Hope
Deputy Base Comptroller
Pope AFB, NC

CMSgt Hudson
Chief of Construction Management
Pope AFB, NC

Robert Jones
Title II Quality Assurance Representative
Shaw AFB, SC

Joe Kirsh
Project Engineer
Shaw AFB, SC

Army

Charles M. Hess
Construction Policy Section
HQ US Army Corps of Engineers
Washington, DC

Bill Miller
Quality Assurance Representative
Fort Bragg / Pope AFB, NC

Mike Smith
Acting Area Engineer
Fort Bragg / Pope AFB, NC

Navy

Lt Keith Berndt
Resident Officer In Charge of Construction
Shaw AFB, SC

Joseph E. Madden
Quality Assurance Representative
Shaw AFB, SC

General Services Administration

Maura Aborn
Contract Specialist
Boston, MA

Hal Bueler
Construction Division
Central Office
Washington, DC

Jim Buzcek
Maintenance Planning
National Capital Region
Washington, DC

Herbert Moore
Area Port Manager
Immigration & Naturalization Service
Houlton, ME

Georger Perry
Project Manager
Boston, MA

Jack Phillips
Title II Construction Inspector
Washington, DC

G. C. Rogerson
Regional Inspection Team
National Capital Region
Washington, DC

Raj Singla
Project Engineer
National Capital Region
Washington, DC

Stuart Steele
Project Manager
National Capital Region
Washington, DC

Vaughn Thompson
Maintenance Planner
Augusta, ME

George Woodward
Immigration Officer
Immigration & Naturalization Service
Houlton, ME

APPENDIX D
CASE STUDY PROJECT SCORE SHEETS

Table D.1 Comptroller Services Center. Score Sheet #1

DEFICIENCY RESOLUTION VS. PERCENT OF COST									
DIVISION	DEFICIENCY CATEGORIES					TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF COST	SCORE
	I	II	III	IV	V				
1	0	0	0	0	1	1	5	5	25
2	0	1	0	0	0	1	2	11.4	22.8
3	2	0	0	0	0	2	2	1.1	2.2
4	0	0	0	0	0	0	0	3.3	0
5	0	0	0	0	0	0	0	1.7	0
6	0	0	0	0	0	0	0	1.6	0
7	0	0	0	0	0	0	0	7.6	0
8	1	0	0	0	1	2	6	3.3	19.8
9	1	0	0	0	2	3	11	19.6	215.6
10						0	0	0	0
11						0	0	0	0
12	0	0	0	0	0	0	0	0.4	0
13						0	0	0	0
14	0	0	0	0	0	0	0	4.4	0
15	4	1	0	0	1	6	11	24.6	270.6
16	7	1	0	0	0	8	9	16.2	145.8
TOTALS	15	3	0	0	5	23	46	100.2	701.8

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - I through V stand for how deficiencies were resolved.

I - Resolved promptly, one point.

II - Resolved slowly or after repetition, two points.

III - Disputed by the contractor, three points.

IV - Accepted by the Government with a credit, four points.

V - Accepted by the Government as is, 5 points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF COST - Percent of construction cost.

SCORE - Weighted Total x Percent of Cost. Low score is best.

Table D.2 Comptroller Services Center. Score Sheet #2**DEFICIENCY SIZE VS. PERCENT OF COST**

DIVISION	SIZE OF DEFICIENCIES			TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF COST	SCORE
	SMALL	MEDIUM	LARGE				
1	0	0	1	1	5	5	25
2	1	0	0	1	1	11.4	11.4
3	2	0	0	2	2	1.1	2.2
4	0	0	0	0	0	3.3	0
5	0	0	0	0	0	1.7	0
6	0	0	0	0	0	1.6	0
7	0	0	0	0	0	7.6	0
8	1	1	0	2	4	3.3	13.2
9	2	0	1	3	7	19.6	137.2
10				0	0	0	0
11				0	0	0	0
12	0	0	0	0	0	0.4	0
13				0	0	0	0
14	0	0	0	0	0	4.4	0
15	4	1	1	6	12	24.6	295.2
16	5	3	0	8	14	16.2	226.8
TOTALS	15	5	3	23	45	100.2	711

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - Broken down into three sizes:

SMALL - Not significant in terms of cost to correct or impact on overall quality, one point.

MEDIUM - Significant cost to correct and potential impact on overall quality, three points

LARGE - Cost to correct is more than original cost of item and serious impact on overall quality, five points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF COST - Percent of construction cost.

SCORE - Weighted Total x Percent of Cost. Low score is best.

Table D.3 Comptroller Services Center. Score Sheet #3

DEFICIENCY RESOLUTION VS. PERCENT OF VALUE

DIVISION	DEFICIENCY CATEGORIES					TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF VALUE	SCORE
	I	II	III	IV	V				
1	0	0	0	0	1	1	5	21.9	109.5
2	0	1	0	0	0	1	2	7.6	15.2
3	2	0	0	0	0	2	2	9.5	19
4	0	0	0	0	0	0	0	9.5	0
5	0	0	0	0	0	0	0	3.8	0
6	0	0	0	0	0	0	0	1.9	0
7	0	0	0	0	0	0	0	7.6	0
8	1	0	0	0	1	2	6	4.8	28.8
9	1	0	0	0	2	3	11	10.5	115.5
10	0	0	0	0	0	0	0	1	0
11	0	0	0	0	0	0	0	1.9	0
12						0	0	0	0
13	0	0	0	0	0	0	0	1	0
14						0	0	0	0
15	4	1	0	0	1	6	11	12.4	136.4
16	7	1	0	0	0	8	9	6.7	60.3
TOTALS	15	3	0	0	5	23	46	100.1	484.7

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - I through V stand for how deficiencies were resolved.

I - Resolved promptly, one point.

II - Resolved slowly or after repetition, two points.

III - Disputed by the contractor, three points.

IV - Accepted by the Government with a credit, four points.

V - Accepted by the Government as is, 5 points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF VALUE - The percentage value toward overall project quality that interviewed military representatives give to each division.

SCORE - Weighted Total x Percent of Value. Low score is best.

Table D.4 Comptroller Services Center, Score Sheet #4

DEFICIENCY SIZE VS. PERCENT OF VALUE

DIVISION	SIZE OF DEFICIENCIES			TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF VALUE	SCORE
	SMALL	MEDIUM	LARGE				
1	0	0	1	1	5	21.9	109.5
2	1	0	0	1	1	7.6	7.6
3	2	0	0	2	2	9.5	19
4	0	0	0	0	0	9.5	0
5	0	0	0	0	0	3.8	0
6	0	0	0	0	0	1.9	0
7	0	0	0	0	0	7.6	0
8	1	1	0	2	4	4.8	19.2
9	2	0	1	3	7	10.5	73.5
10	0	0	0	0	0	1	0
11	0	0	0	0	0	1.9	0
12				0	0	0	0
13	0	0	0	0	0	1	0
14				0	0	0	0
15	4	1	1	6	12	12.4	148.8
16	5	3	0	8	14	6.7	93.8
TOTALS	15	5	3	23	45	100.1	471.4

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - Broken down into three sizes:

SMALL - Not significant in terms of cost to correct or impact on overall quality, one point.

MEDIUM - Significant cost to correct and potential impact on overall quality, three points.

LARGE - Cost to correct is more than original cost of item and serious impact on overall quality, five points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF VALUE - The percentage value toward overall project quality that interviewed military representatives give to each division.

SCORE - Weighted Total x Percent of Value. Low score is best.

Table D.5 Wing Headquarters, Score Sheet #1

DEFICIENCY RESOLUTION VS. PERCENT OF COST

DIVISION	DEFICIENCY CATEGORIES					TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF COST	SCORE
	I	II	III	IV	V				
1	0	1	0	0	0	1	2	5.4	10.8
2	5	1	0	0	0	6	7	10.3	72.1
3	11	0	0	0	0	11	11	10	110
4	13	8	0	0	0	21	29	8.3	240.7
5	7	3	0	0	0	10	13	9.6	124.8
6	0	0	0	0	0	0	0	2.2	0
7	4	1	0	0	0	5	6	4.6	27.6
8	1	1	0	0	0	2	3	4.6	13.8
9	0	0	0	0	0	0	0	13.6	0
10	0	0	0	0	0	0	0	0.4	0
11	0	0	0	0	0	0	0	0.2	0
12	0	0	0	0	0	0	0	0.3	0
13						0	0	0	0
14	0	0	0	0	0	0	0	3.9	0
15	2	1	0	0	0	3	4	11.4	45.6
16	1	2	0	0	0	3	5	15.2	76
TOTALS	44	18	0	0	0	62	80	100	721.4

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - I through V stand for how deficiencies were resolved.

I - Resolved promptly, one point.

II - Resolved slowly or after repetition, two points.

III - Disputed by the contractor, three points.

IV - Accepted by the Government with a credit, four points.

V - Accepted by the Government as is, 5 points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF COST - Percent of construction cost.

SCORE - Weighted Total x Percent of Cost. Low score is best.

Table D.6 Wing Headquarters. Score Sheet #2

DEFICIENCY SIZE VS. PERCENT OF COST							
DIVISION	SIZE OF DEFICIENCIES			TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF COST	SCORE
	SMALL	MEDIUM	LARGE				
1	0	1	0	1	3	5.4	16.2
2	6	0	0	6	6	10.3	61.8
3	9	2	0	11	15	10	150
4	15	6	0	21	33	8.3	273.9
5	7	3	0	10	16	9.6	153.6
6	0	0	0	0	0	2.2	0
7	5	0	0	5	5	4.6	23
8	2	0	0	2	2	4.6	9.2
9	0	0	0	0	0	13.6	0
10	0	0	0	0	0	0.4	0
11	0	0	0	0	0	0.2	0
12	0	0	0	0	0	0.3	0
13				0	0	0	0
14	0	0	0	0	0	3.9	0
15	3	0	0	3	3	11.4	34.2
16	3	0	0	3	3	15.2	45.6
TOTALS	50	12	0	62	86	100	767.5

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - Broken down into three sizes:

SMALL - Not significant in terms of cost to correct or impact on overall quality, one point.

MEDIUM - Significant cost to correct and potential impact on overall quality, three points.

LARGE - Cost to correct is more than original cost of item and serious impact on overall quality, five points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF COST - Percent of construction cost.

SCORE - Weighted Total x Percent of Cost. Low score is best.

Table D.6 Wing Headquarters. Score Sheet #3

DEFICIENCY RESOLUTION VS. PERCENT OF VALUE

DIVISION	DEFICIENCY CATEGORIES					TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF VALUE	SCORE
	I	II	III	IV	V				
1	0	1	0	0	0	1	2	21.9	43.8
2	5	1	0	0	0	6	7	7.6	53.2
3	11	0	0	0	0	11	11	9.5	104.5
4	13	8	0	0	0	21	29	9.5	275.5
5	7	3	0	0	0	10	13	3.8	49.4
6	0	0	0	0	0	0	0	1.9	0
7	4	1	0	0	0	5	6	7.6	45.6
8	1	1	0	0	0	2	3	4.8	14.4
9	0	0	0	0	0	0	0	10.5	0
10	0	0	0	0	0	0	0	1	0
11	0	0	0	0	0	0	0	1.9	0
12						0	0	0	0
13	0	0	0	0	0	0	0	1	0
14						0	0	0	0
15	2	1	0	0	0	3	4	12.4	49.6
16	1	2	0	0	0	3	5	6.7	33.5
TOTALS	44	18	0	0	0	62	80	100.1	669.5

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - I through V stand for how deficiencies were resolved.

I - Resolved promptly, one point.

II - Resolved slowly or after repetition, two points.

III - Disputed by the contractor, three points.

IV - Accepted by the Government with a credit, four points.

V - Accepted by the Government as is, 5 points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF VALUE - The percentage value toward overall project quality that interviewed military representatives give to each division.

SCORE - Weighted Total x Percent of Value. Low score is best.

Table D.8 Wing Headquarters. Score Sheet #4

DEFICIENCY SIZE VS. PERCENT OF VALUE

DIVISION	SIZE OF DEFICIENCIES			TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF VALUE	SCORE
	SMALL	MEDIUM	LARGE				
1	0	1	0	1	3	21.9	65.7
2	6	0	0	6	6	7.6	45.6
3	9	2	0	11	15	9.5	142.5
4	15	6	0	21	33	9.5	313.5
5	7	3	0	10	16	3.8	60.8
6	0	0	0	0	0	1.9	0
7	5	0	0	5	5	7.6	38
8	2	0	0	2	2	4.8	9.6
9	0	0	0	0	0	10.5	0
10	0	0	0	0	0	1	0
11	0	0	0	0	0	1.9	0
12				0	0	0	0
13	0	0	0	0	0	1	0
14				0	0	0	0
15	3	0	0	3	3	12.4	37.2
16	3	0	0	3	3	6.7	20.1
TOTALS	50	12	0	62	86	100.1	733

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - Broken down into three sizes:

SMALL - Not significant in terms of cost to correct or impact on overall quality, one point.

MEDIUM - Significant cost to correct and potential impact on overall quality, three points.

LARGE - Cost to correct is more than original cost of item and serious impact on overall quality, five points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF VALUE - The percentage value toward overall project quality that interviewed military representatives give to each division.

SCORE - Weighted Total x Percent of Value. Low score is best.

Table D.9 Liberty Loan Building. Score Sheet #1

DEFICIENCY RESOLUTION VS. PERCENT OF COST

DIVISION	DEFICIENCY CATEGORIES					TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF COST	SCORE
	I	II	III	IV	V				
1	4	1	0	0	0	5	6	0.5	3
2	4	2	0	0	0	6	8	8.8	70.4
3	1	0	0	1	0	2	5	6.6	33
4	0	0	0	0	0	0	0	1.4	0
5	2	1	0	0	0	3	4	0.6	2.4
6	0	0	0	0	0	0	0	0.7	0
7	2	1	0	0	0	3	4	0.8	3.2
8	5	11	0	0	0	16	27	5.5	148.5
9	4	0	0	0	0	4	4	20.5	82
10	0	0	0	0	0	0	0	0.3	0
11						0	0	0	0
12	0	0	0	0	0	0	0	0.5	0
13						0	0	0	0
14						0	0	0	0
15	18	4	0	0	0	22	26	34.4	894.4
16	1	0	0	0	0	1	1	19.4	19.4
TOTALS	41	20	0	1	0	62	85	100	1256

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - I through V stand for how deficiencies were resolved.

I - Resolved promptly, one point.

II - Resolved slowly or after repetition, two points.

III - Disputed by the contractor, three points.

IV - Accepted by the Government with a credit, four points.

V - Accepted by the Government as is, 5 points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF COST - Percent of construction cost.

SCORE - Weighted Total x Percent of Cost. Low score is best.

Table D.10 Liberty Loan Building. Score Sheet #2

DEFICIENCY SIZE VS. PERCENT OF COST

DIVISION	SIZE OF DEFICIENCIES			TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF COST	SCORE
	SMALL	MEDIUM	LARGE				
1	2	3	0	5	11	0.5	5.5
2	6	0	0	6	6	8.8	52.8
3	1	1	0	2	4	6.6	26.4
4	0	0	0	0	0	1.4	0
5	1	2	0	3	7	0.6	4.2
6	0	0	0	0	0	0.7	0
7	3	0	0	3	3	0.8	2.4
8	15	1	0	16	18	5.5	99
9	2	2	0	4	8	20.5	164
10	0	0	0	0	0	0.3	0
11				0	0	0	0
12	0	0	0	0	0	0.5	0
13				0	0	0	0
14				0	0	0	0
15	21	1	0	22	24	34.4	825.6
16	1	0	0	1	1	19.4	19.4
TOTALS	52	10	0	62	82	100	1199

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - Broken down into three sizes:

SMALL - Not significant in terms of cost to correct or impact on overall quality, one point.

MEDIUM - Significant cost to correct and potential impact on overall quality, three points.

LARGE - Cost to correct is more than original cost of item and serious impact on overall quality, five points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF COST - Percent of construction cost.

SCORE - Weighted Total x Percent of Cost. Low score is best.

Table D.11 Liberty Loan Building. Score Sheet #3

DEFICIENCY RESOLUTION VS. PERCENT OF VALUE

DIVISION	DEFICIENCY CATEGORIES					TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF VALUE	SCORE
	I	II	III	IV	V				
1	4	1	0	0	0	5	6	5.7	34.2
2	4	2	0	0	0	6	8	7.5	60
3	1	0	0	1	0	2	5	11.3	56.5
4	0	0	0	0	0	0	0	1.9	0
5	2	1	0	0	0	3	4	3.8	15.2
6	0	0	0	0	0	0	0	3.8	0
7	2	1	0	0	0	3	4	7.5	30
8	5	11	0	0	0	16	27	5.7	153.9
9	4	0	0	0	0	4	4	18.9	75.6
10						0	0	0	0
11						0	0	0	0
12						0	0	0	0
13						0	0	0	0
14	0	0	0	0	0	0	0	1.9	0
15	18	4	0	0	0	22	26	20.8	540.8
16	1	0	0	0	0	1	1	11.3	11.3
TOTALS	41	20	0	1	0	62	85	100.1	977.5

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - I through V stand for how deficiencies were resolved.

I - Resolved promptly, one point.

II - Resolved slowly or after repetition, two points.

III - Disputed by the contractor, three points.

IV - Accepted by the Government with a credit, four points.

V - Accepted by the Government as is, 5 points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF VALUE - The percentage value toward overall project quality that interviewed military representatives give to each division.

SCORE - Weighted Total x Percent of Value. Low score is best.

Table D.12 Liberty Loan Building. Score Sheet #4

DEFICIENCY SIZE VS. PERCENT OF VALUE

DIVISION	SIZE OF DEFICIENCIES			TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF VALUE	SCORE
	SMALL	MEDIUM	LARGE				
1	2	3	0	5	11	5.7	62.7
2	6	0	0	6	6	7.5	45
3	1	1	0	2	4	11.3	45.2
4	0	0	0	0	0	1.9	0
5	1	2	0	3	7	3.8	26.6
6	0	0	0	0	0	3.8	0
7	3	0	0	3	3	7.5	22.5
8	15	1	0	16	18	5.7	102.6
9	2	2	0	4	8	18.9	151.2
10				0	0	0	0
11				0	0	0	0
12				0	0	0	0
13				0	0	0	0
14	0	0	0	0	0	1.9	0
15	21	1	0	22	24	20.8	499.2
16	1	0	0	1	1	11.3	11.3
TOTALS	52	10	0	62	82	100.1	966.3

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - Broken down into three sizes:

SMALL - Not significant in terms of cost to correct or impact on overall quality, one point.

MEDIUM - Significant cost to correct and potential impact on overall quality, three points.

LARGE - Cost to correct is more than original cost of item and serious impact on overall quality, five points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF VALUE - The percentage value toward overall project quality that interviewed military representatives give to each division.

SCORE - Weighted Total x Percent of Value. Low score is best.

Table D.13 Border Station. Score Sheet #1

DEFICIENCY RESOLUTION VS. PERCENT OF COST

DIVISION	DEFICIENCY CATEGORIES					TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF COST	SCORE
	I	II	III	IV	V				
1	2	2	0	2	1	7	19	1.1	20.9
2	1	1	0	7	3	12	46	16.1	740.6
3	3	7	1	9	8	28	96	13	1248
4	1	2	0	16	0	19	69	6.5	448.5
5	6	5	0	5	0	16	36	11.1	399.6
6	2	3	0	3	0	8	20	3	60
7	5	4	1	3	0	13	28	8.2	229.6
8	2	1	0	16	1	20	73	8.5	620.5
9	1	1	0	14	1	17	64	7.9	505.6
10	0	0	0	0	0	0	0	0.7	0
11	0	0	0	0	0	0	0	0.6	0
12	0	0	0	0	0	0	0	0.2	0
13	0	0	0	0	0	0	0	0.5	0
14	1	0	0	0	0	1	1	2.4	2.4
15	4	0	1	2	0	7	15	11.8	177
16	3	6	0	0	0	9	15	8.6	129
TOTALS	31	32	3	77	14	157	482	100.2	4582

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - I through V stand for how deficiencies were resolved.

I - Resolved promptly, one point.

II - Resolved slowly or after repetition, two points.

III - Disputed by the contractor, three points.

IV - Accepted by the Government with a credit, four points.

V - Accepted by the Government as is, 5 points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF COST - Percent of construction cost.

SCORE - Weighted Total x Percent of Cost. Low score is best.

Table D.14 Border Station. Score Sheet #2

DEFICIENCY SIZE VS. PERCENT OF COST

DIVISION	SIZE OF DEFICIENCIES			TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF COST	SCORE
	SMALL	MEDIUM	LARGE				
1	2	5	0	7	17	1.1	18.7
2	9	3	0	12	18	16.1	289.8
3	14	12	2	28	60	13	780
4	15	4	0	19	27	6.5	175.5
5	4	12	0	16	40	11.1	444
6	5	3	0	8	14	3	42
7	8	5	0	13	23	8.2	188.6
8	19	1	0	20	22	8.5	187
9	13	4	0	17	25	7.9	197.5
10	0	0	0	0	0	0.7	0
11	0	0	0	0	0	0.6	0
12	0	0	0	0	0	0.2	0
13	0	0	0	0	0	0.5	0
14	0	1	0	1	3	2.4	7.2
15	4	3	0	7	13	11.8	153.4
16	3	6	0	9	21	8.6	180.6
TOTALS	96	59	2	157	283	100.2	2664

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - Broken down into three sizes:

SMALL - Not significant in terms of cost to correct or impact on overall quality, one point.

MEDIUM - Significant cost to correct and potential impact on overall quality, three points.

LARGE - Cost to correct is more than original cost of item and serious impact on overall quality, five points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF COST - Percent of construction cost.

SCORE - Weighted Total x Percent of Cost. Low score is best.

Table D.15 Border Station. Score Sheet #3

DEFICIENCY RESOLUTION VS. PERCENT OF VALUE									
DIVISION	DEFICIENCY CATEGORIES					TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF VALUE	SCORE
	I	II	III	IV	V				
1	2	2	0	2	1	7	19	5.7	108.3
2	1	1	0	7	3	12	46	7.5	345
3	3	7	1	9	8	28	96	11.3	1084.8
4	1	2	0	16	0	19	69	1.9	131.1
5	6	5	0	5	0	16	36	3.8	136.8
6	2	3	0	3	0	8	20	3.8	76
7	5	4	1	3	0	13	28	7.5	210
8	2	1	0	16	1	20	73	5.7	416.1
9	1	1	0	14	1	17	64	18.9	1209.6
10						0	0	0	0
11						0	0	0	0
12						0	0	0	0
13						0	0	0	0
14	1	0	0	0	0	1	1	1.9	1.9
15	4	0	1	2	0	7	15	20.8	312
16	3	6	0	0	0	9	15	11.3	169.5
TOTALS	31	32	3	77	14	157	482	100.1	4201

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - I through V stand for how deficiencies were resolved.

I - Resolved promptly, one point.

II - Resolved slowly or after repetition, two points.

III - Disputed by the contractor, three points.

IV - Accepted by the Government with a credit, four points.

V - Accepted by the Government as is, 5 points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF VALUE - The percentage value toward overall project quality that interviewed military representatives give to each division.

SCORE - Weighted Total x Percent of Value. Low score is best.

Table D.16 Border Station. Score Sheet #4

DEFICIENCY SIZE VS. PERCENT OF VALUE

DIVISION	SIZE OF DEFICIENCIES			TOTAL NUMBER	WEIGHTED TOTAL	PERCENT OF VALUE	SCORE
	SMALL	MEDIUM	LARGE				
1	2	5	0	7	17	5.7	96.9
2	9	3	0	12	18	7.5	135
3	14	12	2	28	60	11.3	678
4	15	4	0	19	27	1.9	51.3
5	4	12	0	16	40	3.8	152
6	5	3	0	8	14	3.8	53.2
7	8	5	0	13	23	7.5	172.5
8	19	1	0	20	22	5.7	125.4
9	13	4	0	17	25	18.9	472.5
10				0	0	0	0
11				0	0	0	0
12				0	0	0	0
13				0	0	0	0
14	0	1	0	1	3	1.9	5.7
15	4	3	0	7	13	20.8	270.4
16	3	6	0	9	21	11.3	237.3
TOTALS	96	59	2	157	283	100.1	2450

EXPLANATION:

DIVISION - The sixteen standard divisions used in Government construction specifications.

DEFICIENCY CATEGORIES - Broken down into three sizes:

SMALL - Not significant in terms of cost to correct or impact on overall quality, one point.

MEDIUM - Significant cost to correct and potential impact on overall quality, three points.

LARGE - Cost to correct is more than original cost of item and serious impact on overall quality, five points.

TOTAL NUMBER - Total number of deficiencies in a division.

WEIGHTED TOTAL - For each division, sum of (each category's deficiencies x category points).

PERCENT OF VALUE - The percentage value toward overall project quality that interviewed military representatives give to each division.

SCORE - Weighted Total x Percent of Value. Low score is best.

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